Camille Marie Sears 502 W. Lomita Ave., Ojai, CA 93023

Tel: (805) 646-2588 Fax: (805) 646-6024 e-mail: clouds@rain.org

Summary
I have 25 years of regulatory and private-sector experience in air quality impact analyses, health risk assessments, meteorological monitoring, and geographic information systems. I specialize in litigation support; I have successfully provided testimony in numerous cases, both as an individual consultant and as part of a team of experts.

Education

- M.S., Atmospheric Science, University of California, Davis, 1980.
- B.S., Atmospheric Science, University of California, Davis, 1978.

Air Dispersion Modeling

- I am experienced in applying many different air dispersion models, including programs still in the development phase. I have prepared well over 1,000 air dispersion modeling analyses requiring the use of on-site or site-specific meteorological data. These runs were made with the USEPA ISC, OCD, MESOPUFF, INPUFF, CALPUFF, ISC-PRIME, AERMOD, COMPLEX-I, MPTER, and other air dispersion models.
- I prepared and submitted technical comments to the USEPA on beta-testing versions of AERMOD; these comments are being addressed and will be incorporated into the model and instructions when it is ready for regulatory application.
- I am experienced in performing air dispersion modeling for virtually every emission source type imaginable. I have modeled:
  Refineries and associated activities;
  Mobile sources, including cars, trains, airplanes, trucks, and ships;
  Power plants, including natural gas and coal-fired;
  Smelting operations;
  Area sources, such as housing tracts, biocides from agricultural operations, landfills, airports, oil and gas seeps, and ponds;
  Volume sources, including fugitive emissions from buildings and diesel construction combustion emissions;
  Small sources, including dry cleaners, gas stations, surface coating operations, plating facilities, medical device manufacturers, coffee roasters, ethylene oxide sterilizers, degreasing operations, foundries, and printing companies;
  Cooling towers and gas compressors;
  Diatomaceous earth, rock and gravel plants, and other mining operations;
  Offshore oil platforms, drilling rigs, and processing activities;
  Onshore oil and gas exploration, storage, processing, and transport facilities;
  Fugitive dust emissions from roads, wind erosion, and farming activities;
  Radionuclide emissions from actual and potential releases.
- I have extensive experience in modeling plume depletion and deposition from air releases of particulate emissions.
- As a senior scientist, I developed the Santa Barbara County Air Pollution Control District (SBAPCD) protocol on air quality modeling. I developed extensive modeling capabilities for the SBAPCD on VAX 8600 and Intel I-860 computer systems; I acted as systems analyst for the SBAPCD air quality modeling system; I served as director of air quality analyses for numerous major energy projects; I performed air quality impact analyses using inert and photochemical models, including EPA, ARB and private-sector models; I performed technical review and evaluating air quality and wind field models; I developed software to prepare model inputs consistent with the SBAPCD protocol on air quality modeling for OCD, OCDCPM, MPTER, COMPLEX-I/II and ISC.
- I provided detailed review and comments on the development of the Minerals Management Service OCD model. I developed the technical requirements for and

supervised the development of the OCDCPM model, a hybrid of the OCD, COMPLEX-I and MPTER models.

- I prepared the "Modeling Exposures of Hazardous Materials Released During Transportation Incidents" report for the California Office of Environmental Health Hazard Assessment (OEHHA). This report examines and rates the ADAM, ALOHA, ARCHIE, CASRAM, DEGADIS, HGSYSTEM, SLAB, and TSCREEN models for transportation accident consequence analyses of a priority list of 50 chemicals chosen by OEHHA. The report includes a model selection guide for adequacy of assessing priority chemicals, averaging time capabilities, isopleth generating capabilities, model limitations and concerns, and model advantages.
- I am experienced in assessing uncertainty in emission rate calculations, source release, and dispersion modeling. I have developed numerous probability distributions for input to Monte Carlo simulations, and I was a member of the External Advisory Group for the California EPA *Air Toxics Hot Spots Program Risk Assessment Guidelines, Part IV, Technical Support Document for Exposure Assessment and Stochastic Analysis.*

Health Risk Assessment

- I have prepared more than 300 health risk assessments of major air toxics sources. These assessments were prepared for AB 2588 (the Air Toxics "Hot Spots" Information and Assessment Act of 1987), Proposition 65, and other exposure analysis activities. More than 120 of these exposure assessments were prepared for Proposition 65 compliance verification in a litigation support setting.
- I reviewed approximately 300 other health risk assessments of toxic air pollution sources in California. The regulatory programs in this review include AB 2588, Proposition 65, the California Environmental Quality Act, and other exposure analysis activities. My clients include the California Attorney General's Office, the Los Angeles County District Attorney's Office, the SBAPCD, the South Coast Air Quality Management District, numerous environmental and community groups, and several plaintiff law firms.
- I am experienced in assessing public health risk from continuous, intermittent, and accidental releases of toxic emissions. I am experienced in generating graphical presentations of risk results, and characterizing risks from carcinogenic and acute and chronic noncarcinogenic pollutants.
- I am experienced in communicating adverse health risks discovered through the Proposition 65 and AB 2588 processes. I have presented risk assessment results in many public settings -- to industry, media, and the affected public.
- For four years, I was the Air Toxics Program Coordinator for the SBAPCD. My duties included: developing and managing the District air toxics program; supervising District staff assigned to the air toxics program; developing District air toxics rules, regulations, policies and procedures; management of all District air toxics efforts, including AB 2588, Proposition 65, and federal activities; developing and tracking the SBAPCD air toxics budget.
- I have prepared numerous calculations of exposures from indoor air pollutants. A few examples include: diesel PM_{10} inside school buses, formaldehyde inside temporary school buildings, lead from disturbed paint, phenyl mercuric acetate from water-based paints and drywall mud, and tetrachloroethene from recently dry-cleaned clothes.

Litigation Support

- I have prepared numerous analyses in support of litigation, both in Federal and State Courts. I am experienced in preparing F.R.C.P. Rule 26(a)(2) expert reports and providing deposition and trial testimony (I have prepared eight Rule 26 reports). Much of my work is focused on human dose and risk reconstruction resulting from multiple air emission sources (lifetime and specific events).

- I am experienced in preparing declarations (many dozens) and providing expert testimony in depositions and trials (see my testimony history).
- I am experienced in providing support for legal staff. I have assisted in preparing numerous interrogatories, questions for depositions, deposition reviews, various briefs and motions, and general consulting.
- Recent examples of my work include:
  DTSC v. Interstate Non-Ferrous; United States District Court, Eastern District of California (2002).
  In this case I performed air dispersion modeling, downwind soil deposition calculations, and resultant soil concentrations of dioxins (TCDD TEQ) from historical fires at a smelting facility. I prepared several Rule 26 Reports in my role of assisting the California Attorney General's Office in trying this matter.
  Akee v. Dow et al.; United States District Court, District of Hawaii (2003-2004).
  In this case I performed air dispersion modeling used to quantify air concentrations and reconstruct intake, dose, excess cancer risk, and noncancer chronic hazard indices resulting from soil fumigation activities on the island of Oahu, Hawaii. I modeled 319 separate AREAPOLY pineapple fields for the following chemicals: DBCP, EDB, 1,3-trichloropropene, 1,2-dichloropropane, and epichlorohydrin. I calculated chemical flux rates and modeled the emissions from these fumigants for years 1946 through 2001 (56 years) for 34 test plaintiffs and 97 distinct home, school, and work addresses. I prepared a Rule 26 Expert Report, successfully defended against Daubert challenges, and testified in trial.
  Lawrence O'Connor v. Boeing North America, Inc., United States District Court, Central District of California, Western Division (2004-2005).
  In this case I performed air dispersion modeling, quantified air concentrations, and reconstructed individual intake, dose, and excess cancer risks resulting from approximately 150 air toxics sources in Los Angeles and Ventura Counties, California. I prepared these analyses for years 1950 through 2000 (51 years) for 173 plaintiffs and 741 distinct home, school, and work addresses. I prepared several Rule 26 Reports, and the case settled on the eve of trial in September, 2005. Defendants did not attempt a Daubert challenge of my work.
- I have prepared hundreds of individual and region-wide health risk assessments in support of litigation. These analyses include specific sub-tasks, including: calculating emission rates, choosing proper meteorological data inputs, performing air dispersion modeling, and quantifying intake, dose, excess cancer risk, and acute/chronic noncancer health effects.
- I have prepared over 120 exposure assessments for Proposition 65 litigation support. In these analyses, my tasks include: reviewing AB 2588 risk assessments and other documents to assist in verifying compliance with Proposition 65; preparing exposure assessments consistent with Proposition 65 Regulations for carcinogens and reproductive toxicants; using a geographic information system (Atlas GIS) to prepare exposure maps that display areas of required warnings; calculating the number of residents and workers exposed to levels of risk requiring warnings (using the GIS); preparing declarations, providing staff support, and other expert services as required. I have also reviewed scores of other assessments for verifying compliance with Proposition 65. My proposition 65 litigation clients include the California Attorney General's Office, the Los Angeles County District Attorney's Office, As You Sow, California Community Health Advocates, Center for Environmental Health, California Earth Corps, Communities for a Better Environment, Environmental Defense Fund, Environmental Law Foundation, and People United for a Better Oakland.

Geographic Information Systems

- ArcGIS: I am experienced in preparing presentation and testimony maps using ArcView. I developed methods to convert AutoCAD DXF files to ArcView polygon theme shape files for use in map overlays.

- I have created many presentation maps with ArcView using MrSID DOQQ and other aerial photos as a base and then overlaying exposure regions. This provides a detailed view (down to the house level) of where air concentrations and health risks are projected to occur.
- Using ArcView, I have created numerous presentations using USGS Topographic maps (as TIFF files) as the base on to which exposure regions are overlaid.
- MapInfo for Windows: I prepared numerous presentation maps including exposure isopleths, streets and highways, and sensitive receptors, labels. I developed procedures for importing Surfer isopleths in AutoCAD DXF format as a layer into MapInfo.
- Atlas GIS: I am experienced in preparing presentation maps with both the Windows and DOS versions of Atlas GIS. In addition to preparing maps, I use Atlas GIS to aggregate census data (at the block group level) within exposure isopleths to determine the number of individuals living and working within exposure zones. I am also experienced in geocoding large numbers of addresses and performing statistical analyses of exposed populations.
- I am experienced in preparing large-scale graphical displays, both in hard-copy and for PowerPoint presentations. These displays are used in trial testimony, public meetings, and other litigation support.
- I developed a Fortran program to modify AutoCAD DXF files, including batch-mode coordinate shifting for aligning overlays to different base maps.

Ozone and Long-Range Transport

- I developed emission reduction strategies and identified appropriate offset sources to mitigate project emissions liability. For VOC offsets, I developed and implemented procedures to account for reactivity of organic compound species for ozone impact mitigation. I wrote Fortran programs and developed a chemical database to calculate ozone formation potential using hydroxyl radical rate constants and an alkane/non-alkane reactive organic compound method.
- I provided technical support to the Joint Interagency Modeling Study and South Central Coast Cooperative Aerometric Monitoring Program. With the SBAPCD, I provided technical comments on analyses performed with the EKMA, AIRSHED, and PARIS models. I was responsible for developing emissions inventory for input into regional air quality planning models.
- I was the project manager for the Santa Barbara County Air Quality Attainment Plan Environmental Impact Report (EIR). My duties included: preparing initial study; preparation and release of the EIR Notice of Preparation; conducting public scoping hearings to obtain comments on the initial study; managing contractor efforts to prepare the draft EIR.
- I modified, tested, and compiled the Fortran code to the MESOPUFF model (the precursor to CALPUFF) to incorporate critical dividing streamline height algorithms. The model was then applied as part of a PSD analysis for a large copper-smelting facility.
- I am experienced in developing and analyzing wind fields for use in long-range transport and dispersion modeling.
- I have run CALPUFF numerous times. I use CALPUFF to assess visibility effects and both near-field and mesoscale air concentrations from various emission sources, including power plants.

Emission Rate Calculation

- I developed methods to estimate and verify source emission rates using air pollution measurements collected downwind of the emitting facility, local meteorological data, and dispersion models. This technique is useful in determining whether reported source emission rates are reasonable, and based on monitored and modeled air concentrations, revised emission rates can be created.

- I am experienced in developing emission inventories of hundreds of criteria and toxic air pollutant sources. I developed procedures and programs for quantifying emissions from many air emission sources, including: landfills, diesel exhaust sources, natural gas combustion activities, fugitive hydrocarbons from oil and gas facilities, dry cleaners, auto body shops, and ethylene oxide sterilizers.
- I have calculated flux rates (and modeled air concentrations) from hundreds of biocide applications to agricultural fields. Emission sources include aerial spraying, boom applications, and soil injection of fumigants.
- I am experienced in calculating emission rates using emission factors, source-test results, mass-balance equations, and other emission estimating techniques.

Software Development

- I am skilled in computer operation and programming, with an emphasis on Fortran 95.
- I am experienced with numerous USEPA dispersion models, modifying them for system-specific input and output, and compiling the code for personal use and distribution. I own and am experienced in using the following Fortran compilers: Lahey Fortran 95, Lahey Fortran 90 DOS-Extended; Lahey F77L-EM32 DOS-Extended; Microsoft PowerStation 32-bit DOS-Extended; and Microsoft 16-bit.
- I configured and operated an Intel I-860 based workstation for the SBAPCD toxics program. I created control files and recoded programs to run dispersion models and risk assessments in the 64-bit I-860 environment (using Portland Group Fortran).
- Using Microsoft Fortran PowerStation, I wrote programs to extract terrain elevations from both 10-meter and 30-meter USGS DEM files. Using a file of discrete x,y coordinates, these programs extract elevations within a user-chosen distance for each x,y pair. The code I wrote can be run in steps or batch mode, allowing numerous DEM files to be processed at once.
- I have written many hundreds of utilities to facilitate data processing, entry, and quality assurance. These utility programs are a "tool chest" from which I can draw upon to expedite my work.
- While at the SBAPCD, I designed the ACE2588 model - the first public domain multi-source, multi-pathway, multi-pollutant risk assessment model. I co-developed the structure of the ACE2588 input and output files, supervised the coding of the model, tested the model for quality assurance, and for over 10 years I provided technical support to about 200 users of the model. I was responsible for updating the model each year and ensuring that it is consistent with California Air Pollution Control Officer's Association (CAPCOA) Risk Assessment Guidelines.
- I developed and coded the ISC2ACE and ACE2 programs for distribution by CAPCOA. These programs were widely used in California for preparing AB 2588 and other program health risk assessments. ISC2ACE and ACE2 contain "compression" algorithms to reduce the hard drive and RAM requirements compared to ISCST2/ACE2588. I also developed ISC3ACE/ACE3 to incorporate the revised ISCST3 dispersion model requirements.
- I developed and coded the "HotSpot" system - a series of Fortran programs to expedite the review of air toxics emissions data, to prepare air quality modeling and risk assessment inputs, and to prepare graphical risk presentations.
- I customized ACE2588 and developed a mapping system for the SBAPCD. I modified the ACE2588 Fortran code to run on an Intel I-860 RISC workstation; I updated programs that allow SBAPCD staff to continue to use the "HotSpot" system – a series of programs that streamline preparing AB 2588 risk assessments; I developed a risk assessment mapping system based on MapInfo for Windows which linked the MapInfo mapping package to the "HotSpot" system.
- I developed software for electronic submittal of all AB 2588 reporting requirements for the SBAPCD. As an update to the "HotSpot" system software, I created software that allows facilities to submit all AB 2588 reporting data, including that needed for risk prioritization, exposure assessment, and presentation mapping. The data submitted

by the facility is then reformatted to both ATDIF and ATEDS formats for transmittal to the California Air Resources Board.

- I developed and coded Fortran programs for AB 2588 risk prioritization; both batch and interactive versions of the program were created. These programs were used by several air pollution control districts in California.

Air Quality and Meteorological Monitoring

- I was responsible for the design, review, and evaluation of an offshore source tracer gas study. This project used both inert tracer gas and a visible release to track the onshore trajectory and terrain impaction of offshore-released buoyant plumes.
- I developed the technical requirements for the Santa Barbara County Air Quality/Meteorological Monitoring Protocol. I developed and implemented the protocol for siting pre- and post-construction air quality and meteorological PSD monitoring systems. I determined the instrumentation requirements, and designed and sited over 30 such PSD monitoring systems. Meteorological parameters measured included ambient temperature, wind speed, wind direction, sigma-theta (standard deviation of horizontal wind direction fluctuations), sigma-phi (standard deviation of vertical wind direction fluctuations), sigma-v (standard deviation of horizontal wind speed fluctuations), and sigma-w (standard deviation of vertical wind speed fluctuations). Air pollutants measured included PM_{10}, SO_2, NO, NO_x, NO_2, CO, O_3, and H_2S.
- I was responsible for data acquisition and quality assurance for an offshore meteorological monitoring station. Parameters measured included ambient temperature (and delta-T), wind speed, wind direction, and sigma-theta.
- In coordination with consultants performing air monitoring for verifying compliance with Proposition 65 and other regulatory programs, I wrote software to convert raw meteorological data to hourly-averaged values formatted for dispersion modeling input.
- Assisting the Ventura Unified School District, I collected air, soil, and surface samples and had them analyzed for chlorpyrifos contamination (caused by spray drift from a nearby citrus orchard). I also coordinated the analysis of the samples, and presented the results in a public meeting.
- Using summa canisters, I collected numerous VOC samples to characterize background and initial conditions for use in Santa Barbara County ozone attainment modeling. I also collected samples of air toxics (such as xylenes downwind of a medical device manufacturer) to assist in enforcement actions.
- For the California Attorney General's Office, I purchased, calibrated, and operated a carbon monoxide monitoring system. I measured and reported CO air concentrations resulting from numerous types of candles, gas appliances, and charcoal briquettes.

Support, Training, and Instruction

- For 10 years, I provided ACE2588 risk assessment model support for CAPCOA. My tasks included: updating the ACE2588 risk assessment model Fortran code to increase user efficiency and to maintain consistency with the CAPCOA Risk Assessment Guidelines; modifying the Fortran code to the EPA ISC model to interface with ACE2588; writing utility programs to assist ACE2588 users; updating toxicity data files to maintain consistency with the CAPCOA Risk Assessment Guidelines; developing the distribution and installation package for ACE2588 and associated programs; providing technical support for all users of ACE2588.
- I instructed approximately 20 University Professors through the National Science Foundation Faculty Enhancement Program. Instruction topics included: dispersion modeling, meteorological data, environmental fate analysis, toxicology of air pollutants, and air toxics risk assessment; professors were also trained on the use of the ISC2ACE dispersion model and the ACE2 exposure assessment model.
- I was the instructor of the Air Pollution and Toxic Chemicals course for the University of California, Santa Barbara, Extension certificate program in Hazardous Materials Management. Topics covered in this course include: detailed review of criteria and

noncriteria air pollutants; air toxics legislation and regulations; quantifying toxic air contaminant emissions; criteria and noncriteria pollutant monitoring; air quality modeling; health risk assessment procedures; health risk management; control/mitigating air pollutants; characteristics and modeling of spills and other short-term releases of air pollutants; acid deposition, precipitation and fog; indoor/occupational air pollution; the effect of chlorofluorocarbons on the stratospheric ozone layer. I taught this course for five years.

- I have trained numerous regulatory staff on the mechanics of dispersion modeling, health risk assessments, emission rate calculations, and presentation mapping. I provided detailed training to SBAPCD staff in using the HARP program, and in comparing and contrasting ACE2588 analyses to HARP.
- Through UCSB Extension, I taught a three-day course on dispersion modeling, preparing health risk assessments, and presentation mapping with Atlas GIS and MapInfo.
- I hold a lifetime California Community College Instructor Credential (Certificate No. 14571); Subject Matter Area: Physics.
- I have presented numerous guest lectures – at universities, public libraries, farm groups, and business organizations.

Affiliations

- American Meteorological Society (former president, Ventura/Santa Barbara County Chapter).

Publications

- To establish a legal record and to assist in environmental review, I prepared and submitted dozens of detailed comment letters to regulatory and decision-making bodies.
- I have contributed to over 100 Environmental Impact Statements/Reports and other technical documents required for regulatory decision-making.
- I prepared two software review columns for the *Journal of the Air and Waste Management Association.*

Employment History

• Self-Employed Air Quality Consultant	1992 to 2006
• Santa Barbara County APCD, Senior Scientist	1988 to 1992
• URS Consultants, Senior Scientist	1987 to 1988
• Santa Barbara County APCD, Air Quality Engineer	1983 to 1987
• Dames and Moore, Meteorologist	1982 to 1983
• UC Davis, Research Associate	1980 to 1981

Testimony History

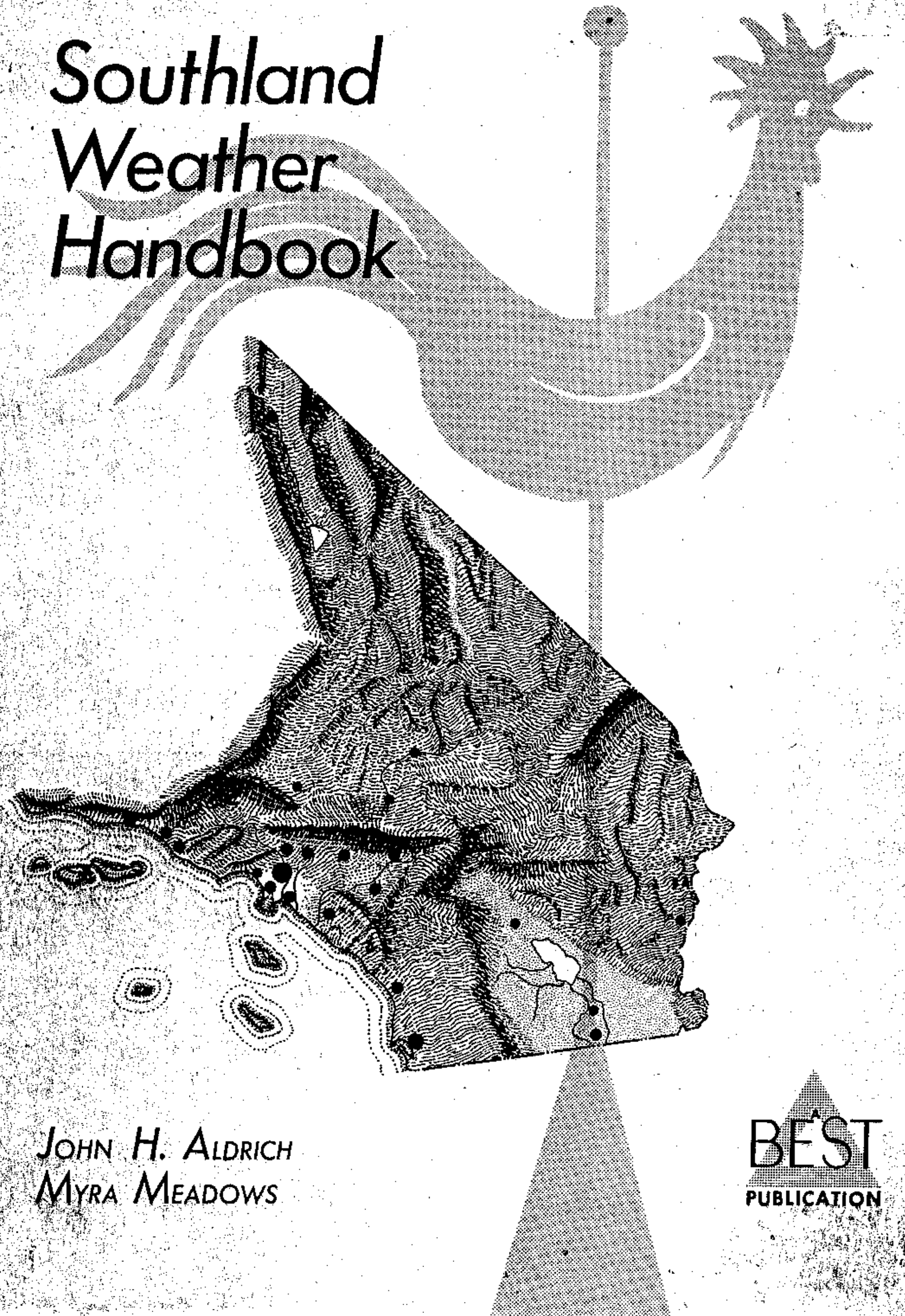
- People of the State of California v. McGhan Medical, Inc.
  Deposition: Two dates: June - July 1990
- People of the State of California v. Santa Maria Chili
  Deposition: Two dates: August 1990
- California Earth Corps v. Johnson Controls, Inc.
  Deposition: October 26, 1995
- Dale Anderson v. Pacific Gas & Electric
  Deposition: January 4, 1996
  Arbitration: January 17, 1996
- Adams v. Shell Oil Company
  Deposition: July 3, 1996
  Trial: August 21, 1996
  Trial: August 22, 1996

- California Earth Corps v. Teledyne Battery Products
  Deposition: January 17, 1997
- Marlene Hook v. Lockheed Martin Corporation
  Deposition: December 15, 1997
- Lawrence O'Connor v. Boeing North America, Inc.
  Deposition: May 8, 1998
- Bristow v. Tri Cal
  Deposition: June 15, 1998
- Abeyta v. Pacific Refining Co.
  Deposition: January 16, 1999
  Arbitration: January 25, 1999
- Danny Aguayo v. Betz Laboratories, Inc.
  Deposition: July 10, 2000
  Deposition: July 11, 2000
- Marlene Hook v. Lockheed Martin Corporation
  Deposition: September 18, 2000
  Deposition: September 19, 2000
- Tressa Haddad v. Texaco
  Deposition: March 9, 2001
- California DTSC v. Interstate Non-Ferrous
  Deposition: April 18, 2002
- Akee v. Dow et al.
  Deposition: April 16, 2003
  Deposition: April 17, 2003
  Deposition: January 7, 2004
  Trial: January 17, 2004
  Trial: January 20, 2004
- Center for Environmental Health v. Virginia Cleaners
  Deposition: March 4, 2004
- Lawrence O'Connor v. Boeing North America, Inc.
  United States District Court, Central District of California,
  Western Division. Case No. CV 97-1554 DT (RCx)
  Deposition: March 1, 2005
  Deposition: March 2, 2005
  Deposition: March 3, 2005
  Deposition: March 15, 2005
  Deposition: April 25, 2005
- Clemente Alvarez, et al, v. Western Farm Service, Inc.
  Superior Court of the State of California
  County of Kern, Metropolitan Division. Case No. 250 621 AEW
  Deposition: April 11, 2005

Other Interests

- I have a small urban farm: CCOF-certified organic since 1997, growing tangerines, figs, cantaloupes, apricots, plums, peaches, herbs, and bamboo.
- I'm also a food and garden writer for Edible Ojai and Edible Communities.

Southland Weather Handbook



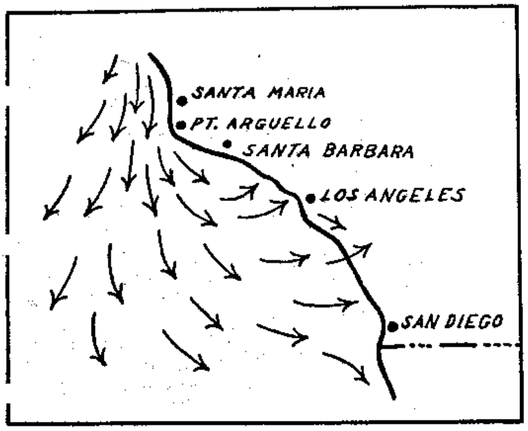
John H. Aldrich
Myra Meadows

A BEST PUBLICATION

Downwind from these jets we find atmospheric whirlpools (eddies), again like water in a stream. South of each jet the air stream swings in a wide arc toward the land, causing belts where we find strong onshore flow of cool air and fog. Other sections of the coast are protected from the wind and fog to a large extent, causing wide variations of weather along the coast. Areas shielded from wind and fog are found mostly on the south side of land projections, or the north side of bays, where the coastline turns sharply inland toward the east. While flying down the coast one can see these eddies of wind and fog quite clearly in some places. Well-known examples of shielded coastline are Santa Cruz, Santa Barbara, and, to a lesser degree, Long Beach.

The most pronounced jets known on the California coast are near Point Sur, south of Monterey Bay, and near Point Arguello, west of Santa Barbara. Both points often experience northerly wind velocities of 30 to 50 miles per hour during the summer half of the year, and Arguello is known by mariners as a graveyard for ships caught in the blast while rounding the point.

The northerly jet of wind at Point Arguello extends in diminishing force to nearby islands, often as far as San Nicolas Island, and produces the largest of the eddies, embracing the area from Arguello to San Diego. It is known as the "Catalina Eddy" and exerts a great influence on our Southland weather.



Typical Catalina Eddy during late afternoon of an average summer day

The main onshore flow of sea air fans out from Santa Monica to below San Diego, reaching the coast from west-southwest in Santa Monica Bay and from west-northwest in San Diego County. Islands and hills cause minor variations in the larger pattern, such as the deflecting influence of the Palos Verde Hills. On the coast northwest of Santa Monica to Santa Barbara the sea air reaches the coast from a more southerly quarter. At Santa Barbara the sea breeze is from southwest, but usually becomes easterly after dark, due to the Catalina Eddy, causing fog to arrive late or not at all.

The sea breeze moves inland over coastal valleys and up the mountain slopes by devious routes, causing a wide variation of temperature and moisture with elevation, varying also with distance inland from the coast. Here terrain plays a major role again, since distance from the coast should be measured by the path of the sea breeze rather than direct airline distance. Long Beach, for example, has a late afternoon sea breeze from north of the Palos Verde Hills, and the air is thus warmed by passing over 8 or 10 miles of land, even though Long Beach is adjacent to the ocean on the south. This quirk of wind flow may also affect Santa Ana, where daytime temperatures compare with those of Burbank, although Santa Ana is much closer to the coast.

Rainfall distribution is influenced heavily by a combination of wind direction and topography. Moisture-bearing winds from the ocean move up the mountain slopes, where forced lifting extracts the moisture from rising air currents. Two principles of physics mentioned earlier will help to explain why. First "expansional cooling" of air as it rises and becomes thinner. Higher altitude means the air weighs less, therefore it expands and becomes cooler. Second, since warm air can hold more moisture than cool air, the cooling process squeezes out the excess moisture that was held by the warmer air at lower elevations. This will help to explain why showers are heavier and more numerous near the mountains than on the coast. The accompanying rainfall chart (Geographical Distribution of Precipitation) shows how rainfall distribution is affected by topography.

Just as the lifting process removes excess moisture, the descending air on the lee side of the range causes warming and drying – warming by compression of heavier air at lower elevations, and drying because the warmer air evaporates some of the moisture. Hence the desert receives much smaller amounts of rainfall, and the weaker storms pass eastward without yielding any measurable amounts of rain over the desert.

The rugged mountain terrain plays another important role with winds from other directions. Winds blowing across the ridges and through the passes have many varied effects, depending on the prevailing direction, stability of the air, strength of the storm and other factors. Desert winds moving down coastal slopes are warmed by compression at lower elevations, bringing clear, dry weather to coastal sections.

Thus we can see that the relation between ocean, valleys, mountains and desert is quite complex, and the role of topography is all-important to our Southland weather. Summarizing a few physical laws that have much to do with our weather:

Warm air is lighter in weight than cool air.

Warm air holds more water vapor than cool air.

Warm air cools from expansion as it rises or is lifted up mountain slopes.

Cool air is warmed by compression as it descends mountain slopes.

Ventura County Air Pollution Control District
669 County Square Drive Ventura, California 93003
tel 805/645-1400 fax 805/645-1444
Richard H. Baldwin Air Pollution Control Officer

December 1, 1994

David P. Howekamp, Director (A-1)
Air & Toxics Division
EPA Region IX
75 Hawthorne Street
San Francisco, CA 94105-3901

Regarding: San Nicolas and Anacapa Islands Attainment Classification

Dear Dave:

I am requesting that your office clarify the attainment classification status of San Nicolas and Anacapa Islands. This issue will be confronting you when you begin to review the Ventura County 1994 AQMP. In the adopted plan, the Air Pollution Control Board specifically exempted San Nicolas Island from requirements in the Plan, subject to a formal determination from EPA that San Nicolas Island is not part of the Ventura County federal ozone nonattainment area.

In the November 6, 1991 federal register, page 56731, EPA designated, for ozone, that all of Ventura County is the Ventura County nonattainment area, and that this area is Severe 15 for ozone. On page 56732, EPA designated the South Central Coast (remainder of), Channel Islands, as unclassifiable/attainment.

For your information, San Nicolas Island and Anacapa Island are part of Ventura County, and are also part of the Channel Islands. Enclosed is a copy of the relevant sections of the California Government Code that identifies the boundaries of counties in California, and specifically identifies the boundary of Ventura County. Also enclosed is Health and Safety Code Section 40002 establishing the district within the entire county.

In the federal register notice, where a nonattainment area boundary is less than a whole county, EPA specifically explains why the boundary is less than the county. In the case of Ventura County, no explanation of a lesser area was described on page 56731. The presumption then is that EPA meant to include all of Ventura County in the Ventura nonattainment area, and that is the definition we have been using since November 6, 1991.

The possibility of a conflict in federal regulations was brought to our attention on September 14, 1994, when the Navy submitted to us a copy of a July 8, 1994 memorandum from Dave Jesson of your staff addressed to "Interested FIP Staff." In this memo Dave states "The Ventura County ozone nonattainment area comprises all of Ventura County except for the Channel Islands, which are an unclassifiable/attainment portion of the South Central Coast Air Basin . . ." This was the first time I was made aware of the possibility of an internal conflict in EPA's designation of the Ventura County ozone nonattainment area. Unfortunately this issue was not discussed with my staff before the memo was released.

Since the Code of Federal Regulations specifies that all of Ventura County is nonattainment for ozone, and also specifies that San Nicolas and Anacapa Islands are unclassifiable/attainment, there is a conflict in federal regulations which we (Ventura) cannot resolve.

I would appreciate your providing to me formal determination of the correct boundary for the Ventura County federal ozone nonattainment area.

Sincerely,

Dick

Richard H. Baldwin
Air Pollution Control Officer

cc: James W. Thonis, Assistant County Counsel
Bill Mount, APCD
Scott Johnson, APCD
James D. Boyd, Executive Officer, ARB
Ron Dow, U.S. Navy, Point Mugu

MINOR NEW SOURCE REVIEW CONSTRUCTION PERMIT APPLICATION

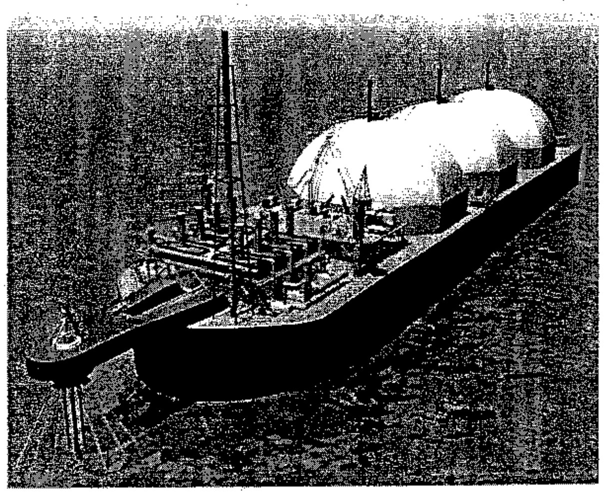
Cabrillo Port

Deepwater Port in the Vicinity of Ventura, California

Submitted to:
United States Environmental Protection Agency
Region IX – Air Division

bhpbilliton

Submitted by:
BHP Billiton LNG International Inc.



December 2005

4. SELECTIVE CATALYTIC REDUCTION UNIT

A selective catalytic reduction unit can be installed to reduce the NOx and VOC emissions. The SCR is installed prior to waste heat recovery units. The urea is injected 3 – 5 meters prior to the SCR unit to ensure proper mixing of urea and exhaust gas. The unit is optimised to reduce emissions in gas mode.

4.1 EMISSION LEVELS

The emission reduction equipment is designed to meet exhaust gas emissions below. The fuel specifications have a significant impact on the emissions levels. The emission levels below are only valid for the fuel specified in chapter 2.1.2. The sulphur content in the liquid fuel will highly determine the SO_x emissions, which can only be specified after the final diesel specification has been reviewed.

4.1.1.1 In gas mode [1]:

NOx	9 ppmv,dry at 15% O_2
CO	20 ppmv,dry at 15% O_2
VOC	40 ppmv,dry at 15% O_2
$PM_{10,dry}$	10 mg/m^3 dry at 15% O_2

4.1.1.2 In diesel mode [1]:

NOx	150 ppmv,dry at 15% O_2
CO	25 ppmv,dry at 15% O_2
VOC	60 ppmv,dry at 15% O_2
$PM_{10,dry}$	21 mg/m^3 dry at 15% O_2

[1] Values at 90% load, not valid at other loads!

4.1.1.3 Applicable measurement methods for emissions:

NO_x USA EPA Method 7E: Determination of nitrogen oxides from stationary sources (instrumental analyzer method).

VOC USA EPA Method 18: Measurement of gaseous organic compound emissions by gas chromatography. VOC is defined as Non Methane Non Ethane Hydrocarbons. Measured components are C3H8, C4H10, C5H12, C6H14, C2H4, C3H6, C4H8, C5H10 and C6H12. Formaldehyde concentration is negligible after a catalyst. If required this can be verified with method CTM-037.

$PM_{10,dry}$ USA EPA Method 17: Determination of particulate emissions from stationary sources (in-stack method)

CO USA EPA Method 10 : Determination of carbon monoxide emissions from stationary sources.

Measurement uncertainties to be evaluated by the party that carries out the measurement. The assessment of the guarantee fulfilment to be performed according to Section 6.2 of the VDI 2048 guidelines.

4.1.1.4 Typical consumption of one SCR unit in gas mode:

Urea cons.(40 wt%) at 100% MCR	19 l/h
Urea cons.(40 wt%) at 90% MCR	17 l/h
Urea cons.(40 wt%) at 75% MCR	16 l/h
Urea cons.(40 wt%) at 50% MCR	14 l/h

4.1.1.5 Typical consumption of one SCR unit in diesel mode:

Urea cons.(40 wt%) at 100% MCR	150 l/h
Urea cons.(40 wt%) at 90% MCR	133 l/h
Urea cons.(40 wt%) at 75% MCR	107 l/h
Urea cons.(40 wt%) at 50% MCR	69 l/h

4.2 SCR UNIT — 4

- one charge of catalysts included

4.2.1 Reagent feeding unit — 1

Including:

- One commom pump for all engines and one stand by pump

4.2.2 Reagent dosing unit — 4

Including flow control dosing, check valve and instrumaentation.

4.2.3 Urea injection system — 4

- including nozzles for atomizing the reducing agent

Blumenthal

2006/P373-A01

Sonoma Technology Inc.

ANALYSIS OF AEROMETRIC AND METEOROLOGICAL DATA
FOR THE VENTURA COUNTY REGION

FINAL REPORT

STI #90094-511-FR

Contract #83-8.0.05(3)-14-01-SOT

Prepared for:

WESTERN OIL & GAS ASSOCIATION (WOGA)
727 W. Seventh Street
Los Angeles, CA 90017

3402 Mendocino Avenue, Santa Rosa, California 95401
707/527-9372

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727 W. Seventh Street
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by

D. L. Blumenthal
T. B. Smith
D. E. Lehrman
N. L. Alexander
Sonoma Technology Inc.

and

F. Lurmann
D. Godden
Environmental Research & Technology Inc.

WOGA Contract Coordinator
William Quinn
Unocal, Los Angeles, CA

June 1986

ABSTRACT

The objectives of the analyses presented in this report are to determine the physical transport mechanisms by which ozone or its precursors are transported from Los Angeles to Ventura County, and to estimate the frequency of occurrence and the contribution to Ventura County ozone concentrations of such transport.

Analyses of data obtained during the Ventura County Ozone Transport (VCOT) Study in September 1983 are presented along with analyses of air quality and meteorological data from 1980-1983. Trajectory model results from selected trajectories from the VCOT Study are also presented. During the VCOT Study, surface and airborne meteorological and air quality measurements were made throughout Ventura County.

Transport from Los Angeles to Ventura County appeared to occur along both coastal and inland routes at the surface and aloft. On days of low mixing heights (<250 m msl), the surface transport routes were favored, and the coastal valley sites could be impacted. Higher mixing heights resulted in elevated layers which could impact the higher elevation coastal and inland sites.

The upper winds at about 1,000 m msl at Point Mugu were used as an indicator of potential transport from Los Angeles to Ventura County. On the average for summer months, ozone concentrations at most Ventura County sites were about 10% higher on days of potential transport than on "non-transport" days. "Transport" winds occurred on about 59% of summer days. During September, "transport" winds were more frequent than in other months, and average ozone concentrations were 40-50% higher on "transport" than on "non-transport" September days at most Ventura County sites.

A photochemical trajectory model was used to simulate five cases where Ventura County ozone exceeded 12 pphm and transport of ozone into the county was likely occurring. The model results indicated that a large fraction of the ozone predicted in Ventura County for these days was due to ozone and its precursors transported from Los Angeles County. Although the model and available input data are too uncertain to precisely quantify the transport component, the model results qualitatively indicate that it can be large under certain meterological conditions.

The data analyses and model results from the VCOT study both indicate that ozone and ozone precursors transported from Los Angeles County can lead to significantly increased ozone concentrations in Ventura County when meteorological conditions are conducive to such transport.

ACKNOWLEDGEMENTS

This work was sponsored by the Western Oil and Gas Association (WOGA) under Contract #83-8.0.05(3)-14-01-SOT. The support of Mr. William Quinn, Contract Coordinator, and the other members of the WOGA Committee who followed the progress of the project is greatly appreciated. This report has also benefitted from many discussions with Dr. Phil Roth and Dr. Stephen Ziman who have reviewed and commented on the project at each stage.

The report would not have been possible without the efforts of several groups who collected, processed, and provided us with much data which was not already available to us through the Ventura County Ozone Transport Study. Specifically, we gratefully acknowledge the contributions of the following groups.

Bureau of Land Management, Minerals Mgt. Service	- Sig Larson
Chevron	- J. E. Morgan
Metro Monitoring Services	- Erwin Kauper
Point Mugu Pacific Missile Test Range	- Robert DeViolini
Rockwell International	- Ms. Pat Casey
Santa Barbara County Air Pollution Control District	- Don Jones
Ventura County Air Pollution Control District	- Evan Shipp and Doug Tubbs

Finally, we thank the staff of STI who did much of the work to produce this report, especially Ms. Stephanie Duckhorn who did most of the typing and graphics and Mr. J. A. McDonald who provided much programming support.

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1. INTRODUCTION, OBJECTIVES, AND PROJECT DESCRIPTION

1.1 INTRODUCTION

Potential oil development on the outer continental shelf offshore of the south central coast of California has raised concerns among regulatory agencies about the impact this development will have on air quality in the adjacent counties. In response to these concerns, the Western Oil and Gas Association (WOGA) has funded several studies of air quality in the region. In 1983, Environmental Research and Technology (ERT) reviewed prior studies for WOGA in order to summarize what was then known about the causes of air quality degradation in the region (Godden and Lague, 1983). This review and additional analyses by Smith et al. (1983) of data from the Santa Barbara Oxidant Study (Lehrman et al. 1981) suggested that transport from the neighboring Los Angeles Basin was probably a significant contributor to high ozone concentrations in Ventura County. It was also apparent that these transport* processes were quite complex, involving day-to-day carryover and elevated layers. The details of the transport mechanisms and the frequency and amount of the transport contribution, however, were not understood.

To address these issues and to provide insights for model development, WOGA sponsored the Ventura County Ozone Transport (VCOT) study in September 1983 and subsequently sponsored the analysis of the VCOT data. This report presents the results of the VCOT study analyses as well as some additional analysis of data from prior years.

The VCOT study was conducted from September 1, 1983 through October 6, 1983, by Sonoma Technology Inc. (STI). Portions of the study were performed under subcontract to STI by AeroVironment, Inc. (AV), Environmental Research and Technology, and Meteorology Research, Inc. (MRI). An instrumented aircraft and supplementary ground based monitors were used to measure the transport of ozone and ozone precursors into Ventura County from Los Angeles (L.A.) County and the three-dimensional distribution of ozone and ozone precursors within Ventura County. The VCOT measurements and the data obtained are presented in a report by Lehrman et al. (1983).

This report was prepared by STI and ERT. Three types of analyses are reported:

1. Case studies of the VCOT study data were performed to determine the transport mechanisms by which ozone or precursors from the L.A. Basin contributed to Ventura County ozone concentrations.

2. Statistical analyses were performed for the VCOT data to assess those meteorological conditions leading to high ozone and to ozone transport in Ventura County. Indicators were developed by which the frequency of transport could be assessed over a longer period than that of the study. Four years of data were then used to determine the frequency of occurrence of days on which transport was likely to be an important contributor to Ventura County ozone concentrations and to assess the representativeness of the September 1983 study period.

3. Determination of the contribution of transported ozone or precursors to surface concentrations is complicated by enroute

* In this report, the term "transport" is generally intended to mean transport from Los Angeles County to Ventura County.

chemistry and local emissions. To provide a rough estimate of the incremental contribution of transported pollutants, a trajectory model was run for selected days and receptors.

The VCOT study was a small exploratory study. The analyses presented here are limited by the constraints of the VCOT data set. This report presents new insights that we have obtained from the data, but it is not a comprehensive analysis of this complex problem and is not intended to answer all questions about the contribution of transport to Ventura County ozone concentrations.

The remainder of this section outlines the objectives of the analyses performed and briefly describes the VCOT measurement program. Section 2 summarizes the conclusions and recommendations from the analyses, and Section 3 presents a conceptual model with case study examples of the synoptic conditions and flow patterns leading to transport.

The details of the analyses are presented in subsequent sections. Section 4 presents several statistical descriptions of the study period. Section 5 assesses the relationships of high ozone in Ventura County to transport and meteorological conditions. The frequency of occurrence of ozone transport into Ventura County is discussed in this section. Section 6 discusses the representativeness of the September 1983 study period, and Section 7 presents the results of trajectory model runs for several transport situations.

1.2 OBJECTIVES

The objectives of this project were to:

1) determine the physical transport mechanisms by which ozone or ozone precursors were transported into Ventura County during the VCOT study period;

2) develop synoptic indicators which correspond with intercounty transport and which can be used to predict such transport and assess its frequency of occurrence;

3) use historical synoptic data and statistical indicators of transport to estimate the representativeness of the VCOT data set and to estimate the frequency and amount of transport of ozone and its precursors;

4) through trajectory model simulations, estimate the sensitivity of surface ozone levels to the ozone and precursor input due to transport; and

5) identify gaps in knowledge and their implications for model development.

1.3 OUTLINE OF VCOT MEASUREMENT PROGRAM

During the study, the STI aircraft made 56 flights, typically three times per day, over a standard route. Airborne measurements included ozone (O_3), nitrogen oxide (NO), total oxides of nitrogen (NO_x), light scattering coefficient, temperature, altitude, and position. Ozone was measured by STI at the Navy facility at Laguna Peak at about 450 m msl elevation. Time-lapse photographs were taken by STI throughout the project during daylight hours at Laguna Peak (2 cameras) and at Big Mountain above Simi Valley. Upper air winds were measured in the Simi Valley with a Doppler acoustic sounder which was operated by AV. Upper winds were also measured at the Ventura Marina using pilot balloons during selected periods of the study by MRI. The data base was augmented by obtaining data from sources external to the project. Ozone and other pollutant monitoring data were obtained from the Ventura County APCD (VCAPCD), the California Air Resources Board (CARB), and Rockwell International (RI) at Rocketdyne. Supplementary meteorological data were obtained from the VCAPCD, the Navy at Point Mugu and Laguna Peak, the FAA at Santa Barbara and Ventura Airports, and RI at Rocketdyne.

Figure 1-1 is a map of the surface monitoring locations discussed in this report, and Figure 1-2 is an outline of the standard flight pattern. The flight pattern consisted of a series of vertical spirals which were generally made from near the surface to the top of the haze layer (1000 - 1500 m msl). Typically, flights were made each day at dawn, midday, and mid-afternoon following the standard pattern. The flights were designed to provide routine observations of the vertical and horizontal distribution of pollutants along the perimeter between Ventura County and the South Coast Air Basin, and to define the vertical temperature and pollutant structure in the boundary layer at several locations. On selected days, the sampling area was extended to include northern portions of Ventura County.

A summary of the meteorology, air quality, and sampling flights during the sampling period is presented in Figure 1-3. The morning 850 mb temperature is plotted as a general indicator of stability and regional stagnation. The peak hourly ozone values measured each day by the VCAPCD are plotted as an indicator of air quality. The occurrence of sampling flights is indicated at the bottom of the figure. Standard or extended sampling flights are indicated by an "S" or "X". Flights cancelled because of weather are indicated by a "W". In general, weather cancellations were due to excessive low clouds or occasionally to rain. The meteorology of the period was unusual for September in that the period was cloudier than usual, and storms were encountered late in the sampling period. The sampling period was also a period of uncommonly persistent southeasterly flow aloft, providing numerous opportunities for intercounty transport. There were 16 days during the sampling period when the federal ozone standard of 0.12 pphm was exceeded in Ventura County.

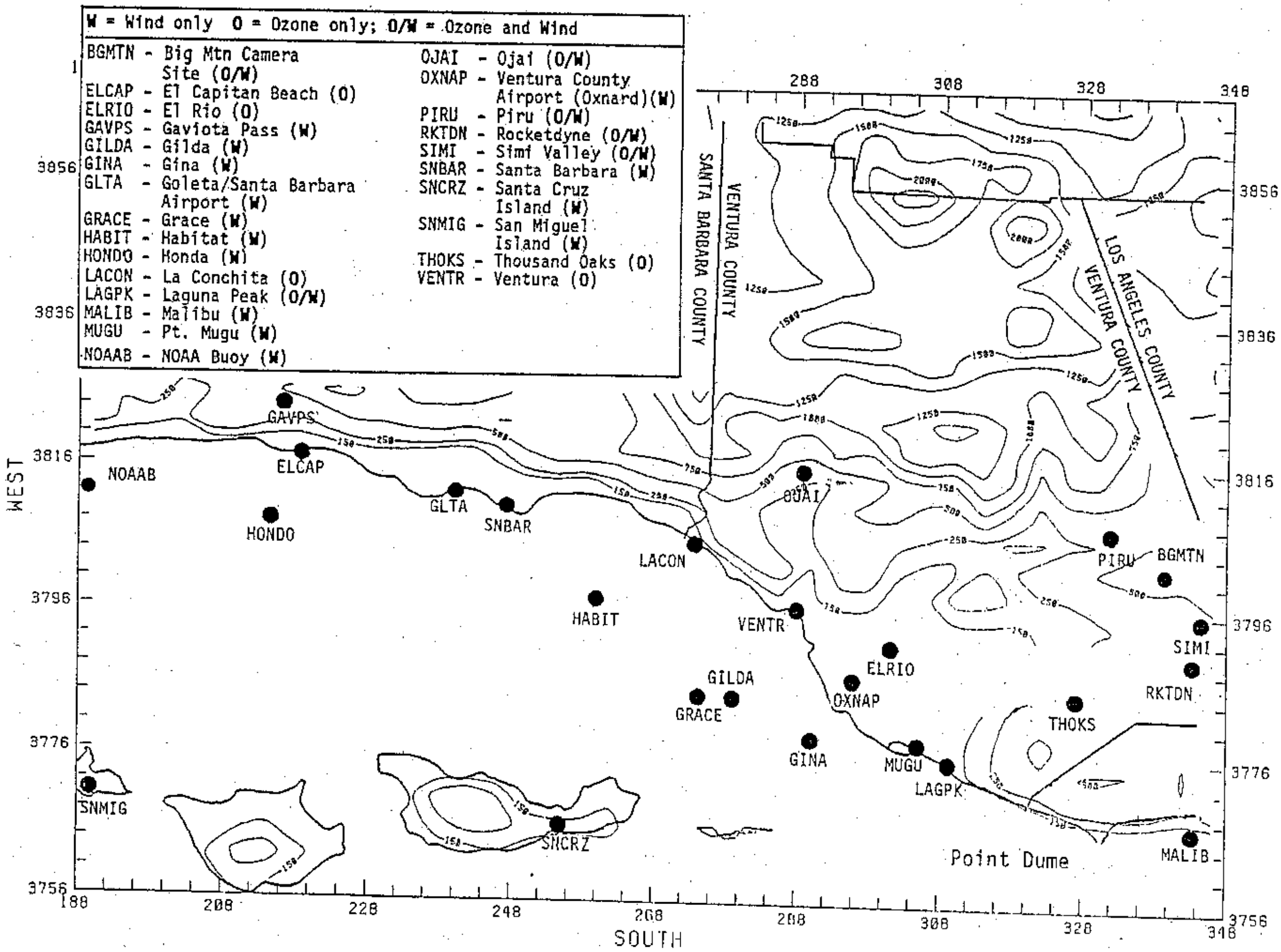

Figure 1-1. Locations of the VCOT Study Surface Monitoring Sites

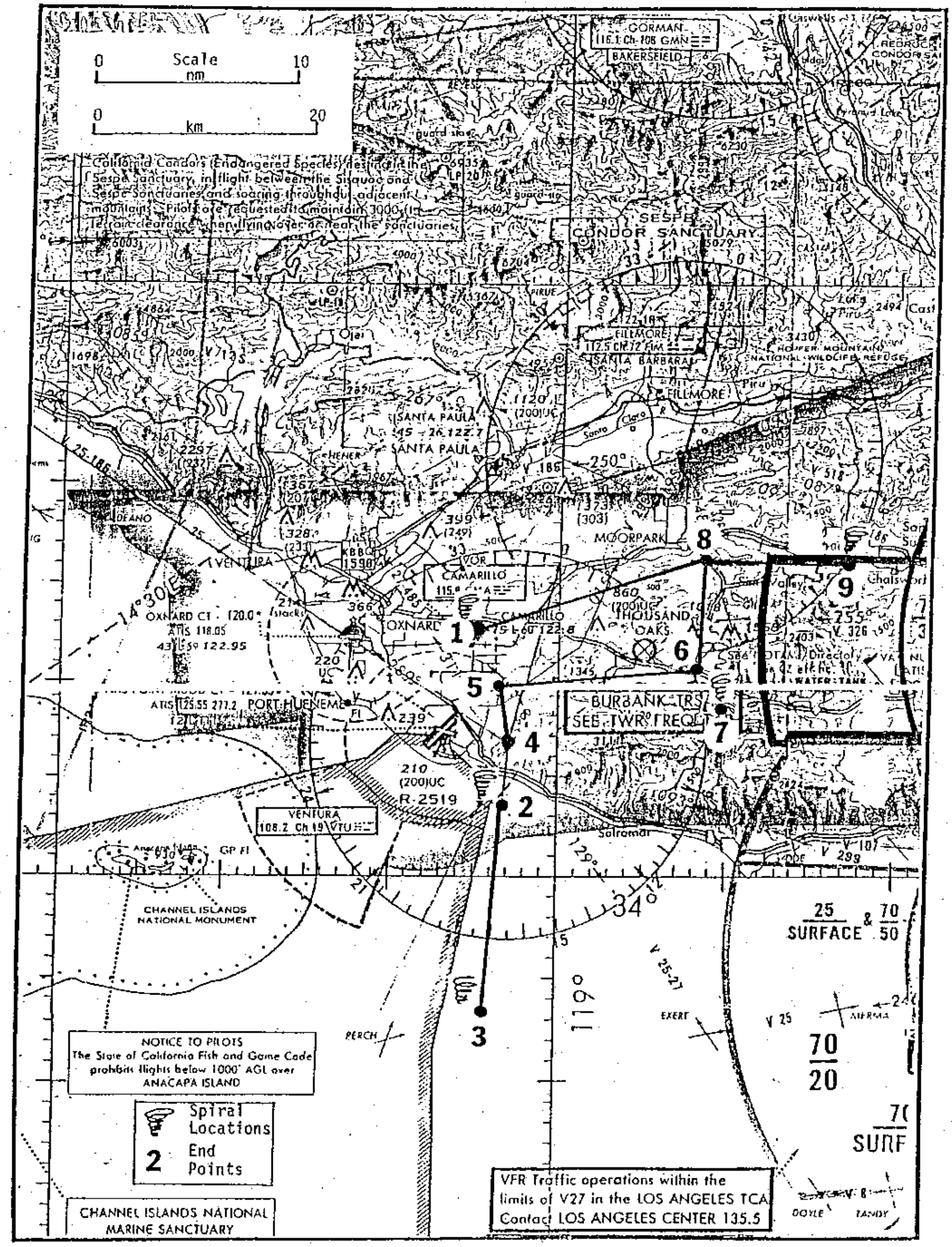

Figure 1-2. Standard Flight Pattern

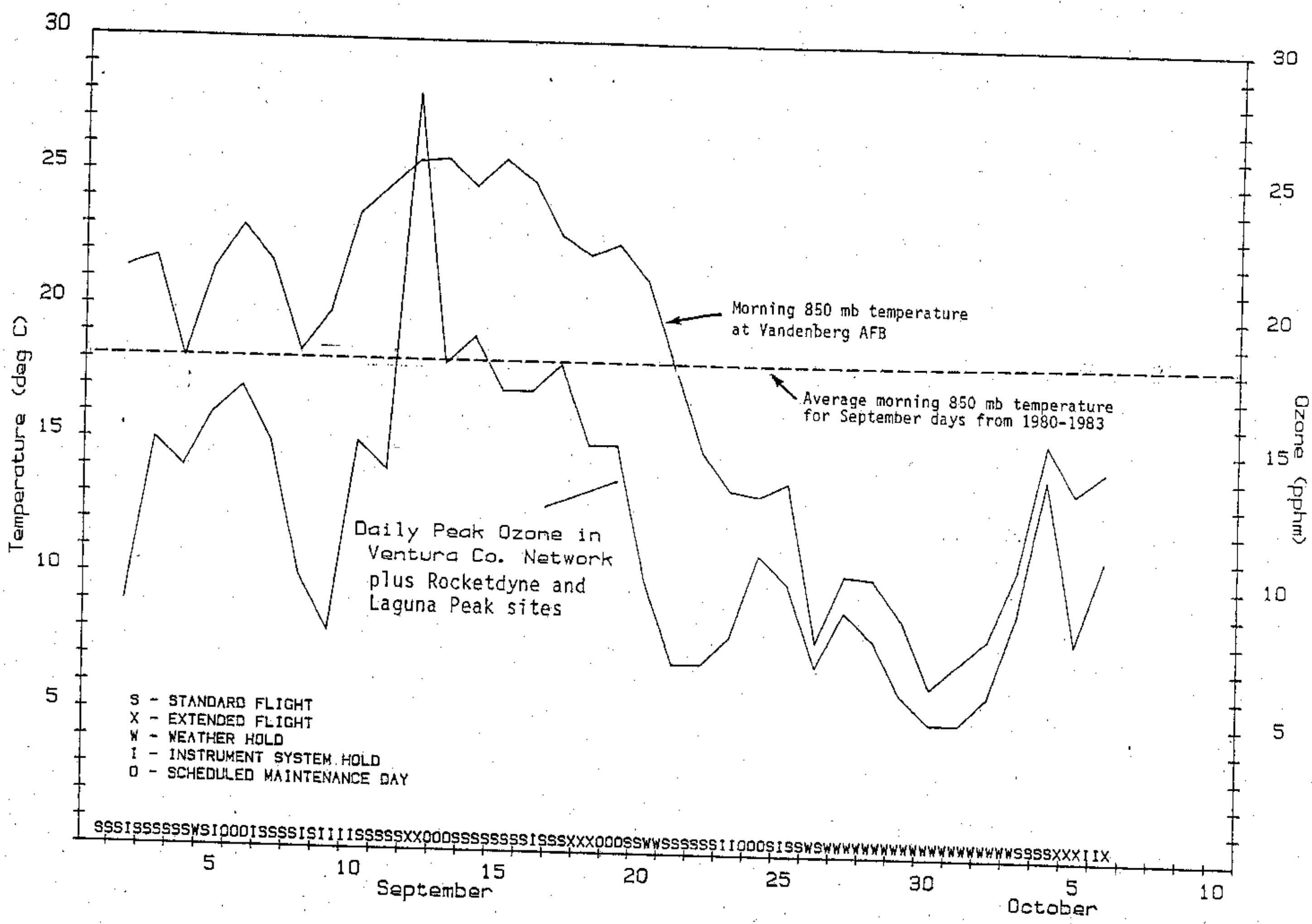

Figure 1-3. Sampling Flight Summary with Air Quality and Meteorology Indices

2. CONCLUSIONS AND RECOMMENDATIONS

2.1 CONCLUSIONS

The conclusions drawn from our analyses of the VCOT Study data and the available 1980-1983 air quality and meteorology data are summarized below.

1. This study and others have shown that pollutants transported from the Los Angeles Basin can be important contributors to coastal and inland ozone concentrations in Ventura County. The upper air wind data at Pt. Mugu indicate that over half the days in each summer month have the potential for such transport contributions. The average percentage of occurrence of potential transport days for June-October, 1980-1983 was 59%. September is clearly the month with the most substantial potential transport effects. June and October have the lowest frequencies of occurrence of potential transport. From this study, however, it does not appear that transport is a prerequisite for exceedances of the Federal ozone standard (12 pphm) to occur in Ventura County.

2. Analysis of the VCOT Study data suggested four mechanisms by which transport can lead to increased Ventura County surface ozone concentrations. Transport was apparent across the Simi Hills (inland route) and along the coast (coastal route). Transport along both routes occurred at the surface and aloft.

   Pollutants transported at low levels (< 250 m msl) along the coast appear to impact coastal valley sites such as El Rio and Ventura. Pollutants transported along the coastal route at higher elevations can directly impact the elevated sites in Ventura County such as Laguna Peak. In addition, elevated coastal pollutants can be brought to the surface farther inland by thermal mixing and can impact areas such as Ojai and Piru. All exceedances at the coastal sites of El Rio and Ventura in June-October from 1980-1983 occurred on days when the air flow aloft was northeasterly through southerly.

   Pollutants transported along the surface from the San Fernando Valley can directly impact areas in eastern Ventura County such as Simi and Rocketdyne. Pollutants transported aloft along the inland route can be brought to the surface by thermal mixing at inland sites near the hills such as Simi, Piru, and Thousand Oaks.

3. The September 1983 VCOT Study period was chosen to look for transport. This period, in fact, had a higher frequency of potential transport days than usually occurs in the summer. During the study, the Ventura County region was affected more than usual by clouds and by tropical moisture, but the 850 mb temperatures and the average ozone maxima were quite close to the averages for Septembers from 1980-1983. Although the VCOT Study period might not be representative

of other summer months, the transport mechanisms suggested by the VCOT data include virtually all feasible transport routes from Los Angeles to Ventura County. Thus, it is likely that the transport mechanisms suggested by the 1983 study are typical of those that occur in other months or years. The frequency of occurrence of the mechanisms, however, is likely to be different during the other summer months. During the 1983 study, all exceedances of the 12 pphm federal ozone standard in Ventura County occurred on days when the wind fields suggested potential transport.

4. The impact of transport into Ventura County depends to a great extent on the depth of the associated mixing layer. Shallow mixing depths tend to produce high ozone concentrations along the immediate coast while deeper mixing layers result in a more elevated ozone layer and impact on the higher elevation inland areas.

5. High (> 12 pphm) ozone days during the VCOT Study typically had the following characteristics:

   - 850 mb temperature was > 20^{o}C
   - Elevated ozone layers existed, especially offshore near Laguna Peak
   - Flow aloft had an easterly component
   - Ozone concentrations were high throughout the South Coast region for extended periods
   - The air mass was relatively stagnant, with mixing heights < 3000'
   - Boundary layer background ozone at approximately 3000' was relatively high: 5-9 pphm.

6. From the 1980-1983 data set, a good indicator of high ozone concentrations in Ventura County was the 850 mb temperature. The 850 mb temperature was greater than 20^{o}C on 66% of exceedance days in Ventura County but on only 17% of non-exceedance days.

7. Maximum ozone levels measured in Ventura County for the 1980-1983 data base were well correlated with levels measured in the South Coast Air Basin. This implies that ozone episodes in Ventura County are typically a regional phenomenon.

8. From the VCOT Study analyses, the 3000' wind direction from the midmorning Pt. Mugu sounding was chosen as an indicator of the potential for transport, with directions from 45^{o} to 180^{o} indicating the potential for transport from Los Angeles County. Days meeting this criterion were considered potential "transport" days for the purposes of various statistical analyses.

For Conclusions 9 - 13 below, the indicator above is used to classify potential "transport" days for the June-October, 1980-1983 Ventura County data.

9. "Transport" and "non-transport" days have similar 850 mb temperature distributions. However, the average 850 mb temperature on "non-transport" exceedance days in Ventura County is higher than for "transport" exceedance days. Thus more trapping and stability is required to exceed the standard on a "non-transport" day.

10. For the summer season at all sites but Ojai, a higher percentage of "transport" days than "non-transport" days had exceedances. In addition, "transport" days accounted for 59% of all days in the four year data set, so most exceedances at most Ventura County sites occurred on "transport" days. The Ojai site appears to be an exception and on the average had lower ozone on "transport" than "non-transport" days. Thus, on the average, Ojai appears to be less affected by transport from L.A. County than other sites in Ventura County.

11. The transport contribution to Ventura County ozone concentrations is most important during September. Exceedances in September at the coastal valley and Thousand Oaks sites only occurred on "transport" days. About 70% of September days in the four year data set were "transport" days. For September, about 46% of "transport" days were exceedance days compared with only 19% of "non-transport" days.

12. On the average for the summer months, the percentage of "transport" days which were exceedance days (O_3 > 12 pphm) in Ventura County was slightly higher than the percentage of "non-transport" (48% vs. 42%). However, the percentages of "transport" vs. "non-transport" days which saw ozone greater than 15 pphm were more biased in favor of "transport" days (21% vs. 14%).

13. For the summer as a whole, the median maximum ozone concentrations at most Ventura County sites were about 10% higher for "transport" than for "non-transport" days. The median maximum ozone concentrations at Ojai and at the San Fernando Valley (L.A. County) sites were higher on "non-transport" days. In September, however, the median maximum ozone values for all sites were higher on "transport" than "non-transport" days, and the Ventura County median maxima were 40-50% higher at many sites on "transport" days.

14. A photochemical trajectory model was used to simulate five cases where Ventura County ozone exceeded 12 pphm and transport of ozone into the county was likely occurring. For these simulations, the ratios of observed to predicted ozone concentrations at the receptor sites averaged within 10% of one for ozone maxima from 140-230 ppb. The model results indicated that a large fraction of the ozone predicted in Ventura County for these days was due to ozone and its

precursors transported from Los Angeles County. Although the model and available input data are too uncertain to precisely quantify the transport component, the model results qualitatively indicate that it can be large under certain meterological conditions.

Sensitivity tests showed that the model predictions were much more sensitive to the initial upwind ozone concentrations than to the initial hydrocarbon or NO_x concentrations.

15. The model results and the VCOT Study results indicate that, on some days, transport can be the dominant factor influencing Ventura County ozone concentrations. These transport contributions are especially important in September and were often dominant during the September 1983 VCOT Study. For the summer as a whole, however, the very high transport components for specific days are diluted in the statistics; the average increase on "transport" days over "non-transport" days is probably more like 10% at most sites in Ventura County. It does not appear that transport is a prerequisite for exceedance of the federal ozone standard.

2.2 GAPS IN KNOWLEDGE AND IMPLICATIONS FOR MODEL DEVELOPMENT

This study has provided a great deal of insight into the transport processes contributing to ozone concentrations in Ventura County. The quantification of the relative contributions of various local and regional sources to ozone concentrations in Ventura County, however, is still subject to a large uncertainty on any given day. To quantify these contributions for specific days or to develop and assess control strategies, it is likely that a sophisticated modeling effort will be needed. Such an effort will need a greatly expanded data base for development and evaluation purposes.

This study has also shown that elevated layers occur frequently in the Ventura County region and impact elevated terrain. The concentrations at the elevated locations can far exceed those measured at valley floor locations. No long term data exist on the magnitude or frequency of this impact or on the effects on vegetation or people at the higher elevations near the coast.

From the 1980-1983 data, it is clear that the transport processes vary from month to month and that any modeling performed should be done for a variety of wind field and meteorological situations. Thus, the data collection effort needed to support the modeling should provide data representative of the spectrum of meteorological regimes seen throughout the summer.

Some specific information needs are outlined below.

1. In order to properly model the transport processes, much more information on the wind fields aloft and offshore will be needed. Diurnal data onshore aloft will be needed to properly predict the

transport of elevated layers. The wind field in the channel at night is quite complex and varies from one night to the next. The nocturnal wind field strongly influences the offshore transport of pollutants. Additional three-dimensional, diurnal wind field data will be needed to assess the offshore circulation patterns and to distinguish pollutants which have been transported into Ventura County from those which have just gone offshore during the night and returned the next day.

2. Mixing downward of ozone from aloft has been indicated along the immediate slopes of the Simi Hills where the mixing layer rises rapidly in mid-day. To the west of this region, the vertical structure over the coastal area is more stratified, and ozone transported from the east tends to remain in distinct layers. The fate of these layers is not certain. They can impact elevated terrain and, if very low, can sometimes affect surface concentrations. However, if they are not carried to the surface, their fate on subsequent days is unknown.

3. The boundary layer background air quality in Ventura County can vary considerably depending on the trajectory of the air arriving in the area. To model surface ozone concentrations, it will be necessary to have good measurements of the background ozone aloft over the region for the types of days to be modeled.

4. There is evidence that ozone and precursors in layers aloft carried over from the previous day, but separated from destructive influences near the surface, may continue reacting when irradiated on the second day. These elevated layers may influence surface concentrations when mixed to the ground in inland areas. The chemistry of these layers aloft needs further attention before it can be incorporated properly into modeling activities. Air quality data useful for validating the nighttime chemistry components of models would be particularly useful (hydrocarbons, NO_x, PAN, etc.).

5. Knowledge of hydrocarbon concentrations and speciation in the layers aloft and in the pollutants transported offshore is currently minimal. Hydrocarbon measurements at these locations as well as at surface onshore locations will be needed as input to the chemical modules of any model used and may also be useful for distinguishing air samples originating in Ventura County from those originating in the South Coast Air Basin. Measurements of oxygenated hydrocarbons (e.g. formaldehyde) would be especially useful to the modeling community.

2.3 RECOMMENDATIONS

Further quantification of the relative contributions of various sources to Ventura County ozone concentrations will likely require a sophisticated modeling effort and substantial additional measurements. The modeling could be performed with a three-dimensional grid model or with multi-layer trajectory models; but in either case, a large amount of data on initial, boundary, and transport conditions will be needed. The wind fields in the region are strongly influenced by terrain, and land-sea interactions and are very complex. They vary greatly from day-to-day, and the frequency of occurrence of various regimes varies from month to month. The pollutant fields have strong horizontal and vertical gradients as well. To obtain the data needed for modeling, it is likely that an intensive three-dimensional data collection effort covering several meteorological regimes will be needed. Since the ozone distribution is a result of multi-day processes, it is clear that three-dimensional data will be required for at least 24-hour periods.

Quantification of the impact of high ozone concentrations in elevated layers on elevated terrain will require the same type of modeling as for the valley sites. In addition, however, to determine the frequency and magnitude of the impact on elevated terrain, some long term monitoring at elevated locations is recommended.

Many of the above requirements will be met by the upcoming South Central Coast Cooperative Aerometric Monitoring Program (Dabberdt, et al. 1985). Some specific measurement recommendations are outlined below.

1. The importance of the wind along the coast at about 1000 m msl has been stressed. A continuous record from a Doppler Acoustic Sounder located on the Oxnard plain would permit a better assessment of the transport wind characteristics.

2. The Laguna Peak location is an excellent place and height to monitor the ozone transport from the South Coast Air Basin into Ventura County. It is also a good location to measure the effects of elevated pollutant layers. Efforts should be made to maintain an ozone monitor at that location to permit a better evaluation of transport throughout the year. Long term data at this site along with the upper wind data mentioned above would be helpful to analysts in quantifying the importance of the transport processes aloft.

3. Additional elevated sites which would be useful additions to the routine monitoring network in Ventura County are the Rocketdyne (or similar) site (which has been operated until recently by Rockwell International) and a site at South Mountain. Data from these sites along with Laguna Peak, could provide a good indication of the frequency and magnitude of elevated layers.

4. The fate and eventual impact on surface concentrations of the elevated layers in the coastal regions could be assessed by tracer releases into the layers. Releases could be conducted in the morning to assess same day impacts and in the evening to assess next day effects.

3. CONCEPTUAL MODEL AND CASE STUDIES OF TRANSPORT FROM THE SOUTH COAST TO THE SOUTH CENTRAL COAST AIR BASIN

3.1 BACKGROUND

An early recognition of the presence of ozone aloft over Ventura County was provided by Lea (1968). High ozone concentrations were frequently found within the temperature inversion at Pt. Mugu at a level of 500-600 m agl. A wind rose was constructed for the altitudes of the high ozone layers coincident with these occurrences. The wind rose indicated that concurrent winds were primarily from northeast to south-southwest and it was concluded that the Los Angeles area was a likely source of the high ozone aloft.

Kauper and Niemann (1975) conducted a brief study of ozone and wind profiles between Santa Monica and Ventura for CARB. Layers of high ozone concentrations were observed aloft within the temperature inversion at both locations. The study period included a three-day ozone episode in Southern California (July 9-11, 1975). The peak ozone concentration observed at Oxnard was listed as 0.43 ppm at 1400 PST on July 10th. This concentration occurred at 900 ft. msl above an inversion base at 700 ft. msl. A trajectory analysis placed this air parcel in the Santa Monica area shortly after midnight on July 9-10. The estimated trajectory was westward and thence north and northeastward, arriving at Oxnard with the afternoon sea breeze flow. Estimated trajectories for high ozone concentrations observed aloft at 1100 PST at Oxnard on nine occasions indicated transport from the San Fernando Valley (3 cases) and along an offshore route from Los Angeles (6 cases). It was suggested that the over-water transport route was more likely when the inversion base was relatively low.

Strange and Hovind (1976) observed an ozone layer (or layers) aloft in an aircraft flight between Santa Barbara and Ventura. The peak ozone reported was 25 pphm at 1400 ft. msl within the temperature inversion offshore from Ventura. The time of the flight was about 1500 PST on August 25, 1976.

Shair et al. (1982) conducted an SF_6 tracer study by releasing material from the stack of a power plant in El Segundo between 2300 and 0400 PST on July 22, 1977. The tracer material was carried offshore by the land breeze and subsequently returned to the coast by the afternoon sea breeze. Significant concentrations of SF_6 were observed along the coast between Ventura and Pt. Mugu beginning at 1100-1200 PST and continuing through 1600 PST. The bulk of the material, however, returned to the coast within the South Coast Air Basin.

An extensive tracer and observational study was carried out in the Santa Barbara/Ventura area by CARB in September 1980 (Smith et al., 1983). Results of the study are of interest from a transport standpoint in the following ways:

1. Tracer releases (October 1 and 3, 1980) were made between Port Hueneme and Platform Grace during the morning (0500-1000 PST and 2345-0445 PST, respectively). Tracer trajectories indicated transport as far west as Santa Barbara before the sea breeze wind flow reversal.

These trajectories indicate that significant transport into Santa Barbara from the southeast can occur over distances of 100 km or more.

2. Afternoon aircraft soundings (September 28 and October 3, 1980) near the Simi Hills showed strong ozone layers aloft (23 and 13 pphm, respectively) at elevations of about 1000-1200 m msl. These layers were observed to be associated with east or southeast winds and appear to have been transported from the San Fernando Valley to the eastern edge of the South Central Coast Air Basin.

3. On October 2, 1980, anomalous ozone peaks were observed at Ventura and Port Hueneme between 1900 and 0000 PST, well after the diurnal ozone maximum had occurred. Ozone readings at Platform Grace indicated a peak value of 13 pphm at 1200 PST with a southeast wind. Subsequently, the wind shifted to a westerly, sea breeze direction. Backward trajectories indicated that the high ozone concentrations at Platform Grace and, during the evening along the coast, probably originated in the South Coast Air Basin and were then transported northwest offshore into the South Central Coast Air Basin.

Finally, Godden and Lague (1983) provide detailed summaries of the available literature regarding possible pollutant transport between the South Coast and South Central Coast Air Basin.

The information summarized above provides strong indications of pollutant transport from the South Coast to the South Central Coast Air Basin under appropriate meteorological conditions. Two transport routes have been suggested:

1. Offshore from the Santa Monica/LAX area and thence northwestward to the Ventura/Pt. Mugu area where the material may be brought onshore by the sea breeze.

2. Transport from the San Fernando Valley westward into the South Central Coast Air Basin where concentrations aloft might be fumigated to the surface.

3.2 CONCEPTUAL MODEL OF TRANSPORT

The foregoing studies and the results of the September 1983 field program lead to the following scenarios for transport from the South Coast Air Basin to the South Central Coast Basin.

3.2.1. Offshore Transport

During the night and early morning hours of summer, low-level winds along the Southern California Coast frequently have an easterly component. Table 3-1 gives the frequency of occurrence of offshore winds at Loyola-Marymount (near LAX) and at Pt. Mugu for several months of the summer during the years of 1980-83.

Table 3-1. Frequency of Occurrence of Early Morning Offshore Winds (0500 PST)

Month	Height (ft. agl)	Frequencies Loyola-Marymount (%)	Frequencies Pt. Mugu (%)
July	1000	66	69
	2000	68	68
	3000	46	48
August	1000	63	66
	2000	56	77
	3000	45	77
September	1000	59	54
	2000	67	63
	3000	62	64

As indicated in Table 3-1, the coastal winds at night frequently have the potential for transport of pollutants into the offshore areas. The extent of this transport and the height at which it occurs are highly dependent on the overall synoptic weather conditions. Above normal pressure gradients from the coast to the inland areas decrease the effectiveness of the offshore transport while weak onshore or offshore pressure gradients increase the opportunity for such transport. It is often apparent that a shallow onshore flow layer may exist during the night near the surface underneath an offshore flow at 2000-3000 ft. Consequently, the surface winds along the coast are not always reliable indicators of the existence of offshore flow. The nocturnal pollutant transport may occur in the shallow layer near the surface or in an elevated layer separated from the surface.

Heating of the inland areas during the day typically initiates a sea breeze flow along the coast. Table 3-2 gives the median initiation times for the sea breeze at Pt. Mugu and LAX.

Table 3-2. Median Development of the Sea Breeze Flow at Pt. Mugu and LAX (obtained from surface data for 1979 and 1980)

	Pt. Mugu		LAX	
	Beginning (PST)	End	Beginning (PST)	End
July	0900	1900	0900	2200
August	0900	1900	0900	2300
September	0900	1800	0900	2100

The sea breeze flow has characteristically stronger velocities than the nocturnal flow but, in the case of Pt. Mugu, is present for a shorter portion of the 24 hour day.

The sea breeze flow provides a mechanism for the return of pollutants which have been transported offshore during the previous night. As suggested by the above data, this process may occur in the Ventura area as well as the South Coast Air Basin.

The trajectory of pollutant material carried offshore from the South Coast Air Basin is determined largely by the overall meteorological situation. This was well illustrated by Shair et al. (1982) who released tracers on successive nights from the South Coast Basin. Tracers released one night returned to the coast at Ventura and Santa Monica, while the tracer released the next night returned to the region between Santa Monica and Long Beach.

Schematic trajectories indicating the transport routes between the South Coast and the South Central Coast Air Basins are shown in Figure 3-1. As expected in any transport situation, the impact of the transport is influenced strongly by the dispersion which occurs along the transport route. Offshore transport from the South Coast Air Basin to the South Central Coast Basin may occur but may have insignificant impact due to extensive mixing along the route.

3.2.2 Transport from the San Fernando Valley

Another potential transport route from the South Coast Air Basin to the South Central Coast Basin is from the San Fernando Valley over the Simi Hills into the eastern portions of Ventura County. Since the San Fernando Valley experiences high ozone concentrations during the summer months, there is reason to expect that easterly winds could transport these pollutants into the South Central Coast Air Basin.

The diurnal distribution of winds across the Simi Hills is similar to that observed along the coast. The frequency of easterly winds increases at night and in the early morning but decreases markedly during the afternoon when the sea breeze dominates the flow. The median beginning and ending times of the westerly flow at Rocketdyne (1800 ft. msl in the Simi Hills) are shown in Table 3-3.

Table 3-3. Median Development of Westerly Flow at Rocketdyne (1981-83)

	Begin	End
July	1100 PST	2100 PST
August	1100	2100
September	1200	2000

A series of pibal wind soundings at Simi at 0400 PST during September 1980 showed a frequency of about 70% for north-northeast to southeast winds at 1000 m msl which is a reasonable transport level across the Simi Hills.

From Table 3-3, there is a potential for easterly surface transport into the South Central Coast Air Basin until a median time of 1100 to 1200 PST. Although there is a realistic potential for transport into the Basin, the impact of this transport needs to be considered.

Table 3-4 shows the median top of the mixing layer at Camarillo and Simi in September 1983 for several times of day. These heights were obtained from the VCOT aircraft soundings.

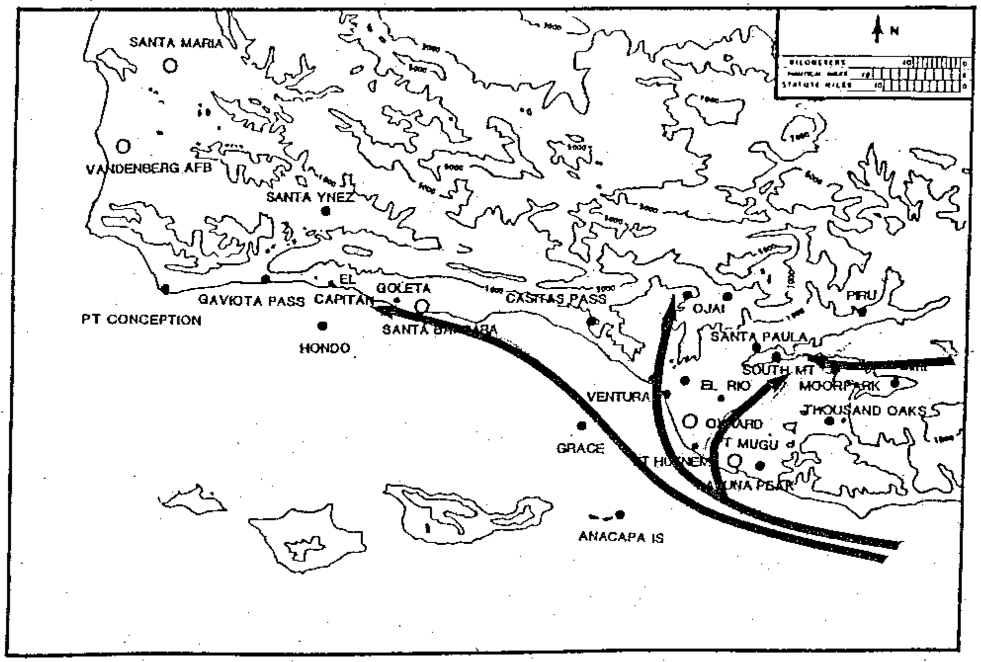

Figure 3-1. Schematic View of Transport Routes from the South Coast Air Basin to the South Central Coast Air Basin.

Table 3-4. Median Top of Mixed Layer During the VCOT Aircraft Soundings (September 1983)

Camarillo		Simi	
Approximate Time (PST)	Top of Mixing (m msl)	Approximate Time (PST)	Top of Mixing (m msl)
0600	100	0700	400
0900-1000	300	1000	750
1400-1500	300	1600	750

The data in Table 3-4 indicate that the mixing depth in the Simi area frequently reaches a height above the Rocketdyne station (elev. 550 m msl), and hence any pollutant material moving westward past Rocketdyne could be readily incorporated in the mixed layer and brought down to the level of Simi (elev. 335 m msl). The timing of the mixed layer growth to the level of the Rocketdyne station is generally indicated by the shift to a northwesterly wind at Rocketdyne. From Table 3-3, this occurs with a median time of 1100-1200 PST.

Table 3-4, however, indicates a much lower mixing layer top at Camarillo which can be considered as representative of the coastal plain. The data in the table suggest that the mixing depth at Camarillo does not usually reach the altitude of the Rocketdyne station. Pollutant material carried westward over the plain would therefore be unlikely to be mixed down directly to the surface layers near the coast.

The fate of this elevated pollutant layer moving westward is somewhat uncertain. Mixing downward over the coastal plain is severely inhibited by the temperature inversion which exists above the sea breeze flow. Whether the elevated layer can be carried out over the ocean and incorporated in the next day's sea breeze is not known. The layer could, however, impact on higher terrain to the south and northwest of the Ventura coastal plain, e.g. Laguna Peak and Ojai. In addition, ventilation to the surface at Piru would probably occur in a similar way as at Simi.

Lidar data (McElroy, 1983) have confirmed that the region of potential interchange between surface layers and the elevated layer is confined to a distance of 15-20 km westward from the crest of the Simi Hills. Beyond this distance, the depth of the mixed layer is not sufficient to bring about the interchange. This limits the direct impact of transport from the San Fernando Valley to a narrow distance along the western slopes of the Simi Hills and to the upper reaches of the Santa Clara River valley where rising terrain and slope heating combine to bring about rapid increases in mixing depth.

3.3 CASE STUDIES

The inland and coastal (over-water) transport routes described above have been further sub-divided into surface and elevated categories.

representing the relative altitude of transport. Three case study days from the September 1983 VCOT sampling period are described below which illustrate these various routes. More than one route can occur on a given day.

3.3.1 September 11, 1983

3.3.1.1 General Meteorology

High pressure was present in the Pacific Northwest (Figure 3-2), following the passage of a low pressure system through the area on the 10th. The surface thermal low pressure area extended as far north as northern California but was located along the coast, to the west of its normal summer position. The pressure gradient aloft (500 mb) was very flat with light, easterly winds at most locations in California and southern Nevada. High scattered clouds were reported during the day in the South Central Coast Air Basin. Lowest visibilities reported during the day were 8 miles at Pt. Mugu. No low clouds were observed on the 11th below 5000 ft msl.

Significant meteorological parameters for September 11, 1983 are summarized in Table 3-5.

Table 3-5. Meteorological Parameters for September 11, 1983

	9/11/83	Long Term Average*
850 mb Temperature at 0400 PST (Vandenberg AFB)	$24.5^{o}C$	$18.1^{o}C$
Surface Pressure Gradients (0400 PST)		
San Francisco - Reno	-5.1 mb	-1.2 mb
Los Angeles - Bakersfield	-3.2	-0.1
Los Angeles - Las Vegas	-2.4	1.6
Inversion Bases		
Loyola-Marymount (0600 PST)	surface	
Loyola-Marymount (1100 PST)	250 m agl	
Upper Winds (1000 m msl)		
Loyola-Marymount (0600 PST)	030^{o}/1 m/s	
Loyola-Marymount (1100 PST)	330^{o}/1.5 m/s	
(Pt. Mugu Sounding data not available)		

*average September values (1980-83)

Meteorological conditions on September 11, 1983 reflected the early phases of an extended period of warm temperatures aloft and relatively high ozone concentrations. This sequence began on September 10th and lasted through September 19th. By September 11th, the temperature at 850 mb was well above average, and the surface pressure gradients were strongly directed offshore from central California to southern California. These conditions represent the initial stages of a characteristic cycle which begins with offshore

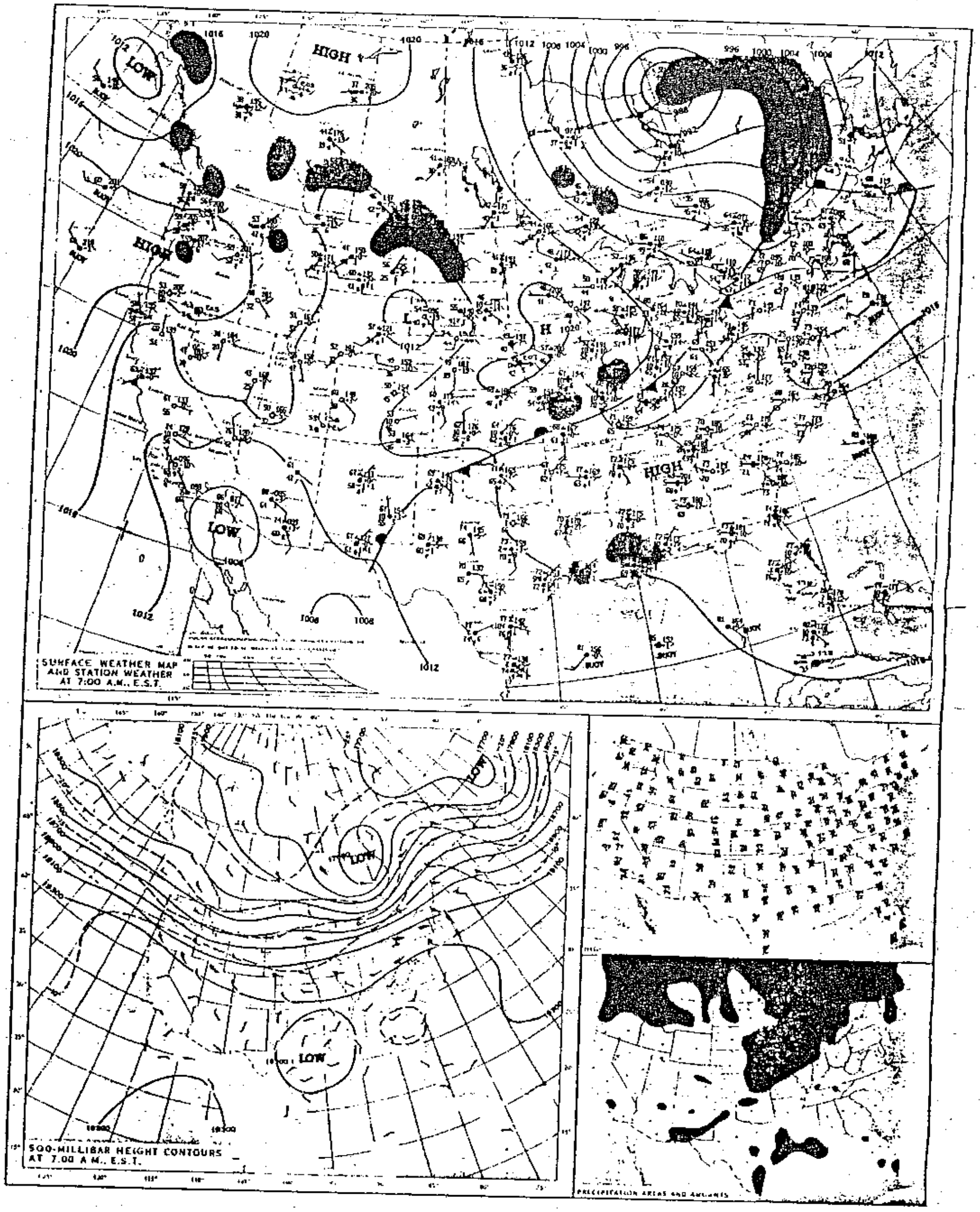

Figure 3-2. Surface and 500 mb Synoptic Weather Maps for 11 September 1983 at 0400 PST.

transport of pollutants, passing through a stage of stagnant conditions (weak pressure gradients) and ending with the return of onshore gradients and a stronger westerly flow.

3.3.1.2 Transport Winds

Table 3-6 gives the surface wind observations for several locations of interest on September 11th.

Table 3-6. Surface Transport Wind Summary for September 11, 1983

Time (PST)	Laguna Peak (degrees/ m/s)	Platform Grace (degrees/ m/s)	Pt. Mugu (degrees/ m/s)	Santa Barbara (degrees / m/s)
0600	calm	356/0.9	030/1	calm
0800	calm	320/1.7	calm	calm
1000	calm	262/3.3	250/1	250/3
1200	230/2	259/3.6	260/2	240/4
1400	260/3	230/5.9	260/3	240/6
1600	320/6	277/4.8	300/2	240/6
1800	330/7	243/7.1	300/2	210/3
2000	310/8	256/4.5	320/1	130/2
2200	290/6	224/3.3	290/3	calm

A summary of wind directions at 1000 m msl obtained by the doppler acoustic sounder at Simi is given in Table 3-7. Recorded wind speeds at that level were higher than could be substantiated by other data and are not presented.

Table 3-7. Doppler Acoustic Sounder Wind Directions at Simi at 1000 m msl for September 11, 1983

Time (PST)	Wind Direction (degrees)	Time (PST)	Wind Direction (degrees)
0800	025	1600	145
1000	135	1800	162
1200	141	2000	142
1400	146	2200	267

The surface wind flow patterns on September 11th indicated southwest to northwest winds during the midday and afternoon hours throughout the area. There was no indication of southerly flow in the offshore area which could have transported pollutants from the South Coast Air Basin at surface levels.

The 1000 m msl winds at Simi were consistently from the southeast until late in the evening. West-southwest winds existed at Simi to levels of 600 m msl by 1200 PST, increasing to a 1000 m msl top by 2200 PST.

3.3.1.3 Mixing Heights

The primary sources of mixing height data are aircraft soundings where an evaluation of the pollutant and temperature profiles usually provides a good indication of the effective mixing depth. A summary of the aircraft sounding data for September 11th is shown in Table 3-8.

Table 3-8. Mixing Heights from Aircraft Soundings for September 11, 1983

	Time (PST)	Mixing Depth (m agl)
Camarillo (sfc. elev. 25 m)		
	0519	50
	0920	75
	1412	275
Pt. 2 (3 mi SSW Laguna Peak, over water)		
	0532	100
	0932	100
	1426	125
Pt. 3 (13 mi. SSW Laguna Peak, over water)		
	0554	225
	0948	200
	1443	150
Westlake Reservoir(sfc.elev. 305 m)		
	0622	100
	1015	200
	1510	300
Simi (sfc.elev. 335m)		
	0639	-
	1033	165
	1527	295

As indicated in Table 3-8, all mixing heights were relatively low, in keeping with the warm temperatures aloft. Mixing heights over the land areas increased substantially during the day but remained relatively low compared to average conditions.

3.3.1.4 Regional Ozone Concentrations

Maximum ozone concentrations observed in the South Central Coast Air Basin on September 11th are given in Table 3-9 together with the times of observance of the maximum values and the winds observed at the monitoring stations at the times of the maxima.

Table 3-9. Maximum Hourly Ozone Concentrations on September 11, 1983

Location	Maximum Concentration (pphm)	Time of Maximum (PST)	Wind (deg/(m/s)
Ojai	M*	M	
Piru	11	13	264/M
Simi	10	15-17	285/3
Thousand Oaks	12	13	
Rocketdyne	11	14	329/5
El Rio	14	15-16	
Laguna Peak	11	15	270/6
Ventura	10	16	270/5
La Conchita	10	15	
Santa Barbara	12	13	270/4
Goleta	13	13	
El Capitan Beach	9	14-15	

* M = missing data

Observed exceedances of the 12 pphm ozone standard occurred at El Rio and Goleta. In contrast to the normal occurrence, high ozone values were observed near the coast rather than in the inland areas. As will be indicated later, this situation frequently occurs under conditions of very low mixing height.

3.3.1.5 Transport Analysis

Figure 3-3 shows the hourly ozone concentrations for a number of stations in Ventura County on September 11th. The diurnal patterns are characterized by relatively late ozone peaks. Average ozone maxima in Ventura County occur about 1300-1400 PST (Smith et al., 1983). Although there are indications of an earlier peak in the Figure 3-3 data (e.g. Piru) there is evidence of a somewhat stronger peak at 1600-1700 PST (1500 PST at Laguna Peak). It is also to be noted that the peaks at Simi and Piru are extended through 1700 PST. The data tend to suggest a peak which arrived first at Laguna Peak and subsequently at Ventura/El Rio and then at Piru/Simi. In contrast, Santa Barbara and Goleta had single ozone peaks, centered at 1300 PST.

Figures 3-4 through 3-7 show early morning aircraft soundings for September 11th at Camarillo, at two offshore locations, and at Westlake Reservoir. All of these soundings show significant temperature inversions in the low layers but are without any indications of high ozone concentrations aloft. The peak ozone concentration reported on any of the soundings was about 8 pphm. Available wind observations at Loyola-Marymount showed southeasterly winds in the lowest 300 m at 0600 PST. Doppler acoustic sounder winds at Simi indicated a shallow southeasterly flow in the lowest 150 m agl. There were no sounding observations taken at Pt. Mugu on September 11th.

Figures 3-8 and 3-9 show the aircraft soundings made at Camarillo and offshore at 3 mi SSW of Laguna Peak in the late morning. A shallow mixing layer had developed at Camarillo due to surface heating. A peak ozone concentration of 11 pphm occurred near the base of the temperature inversion. Offshore, the surface temperature inversion remained, and a peak ozone value of 17 pphm existed at a level of 150-200 m msl within the temperature inversion.

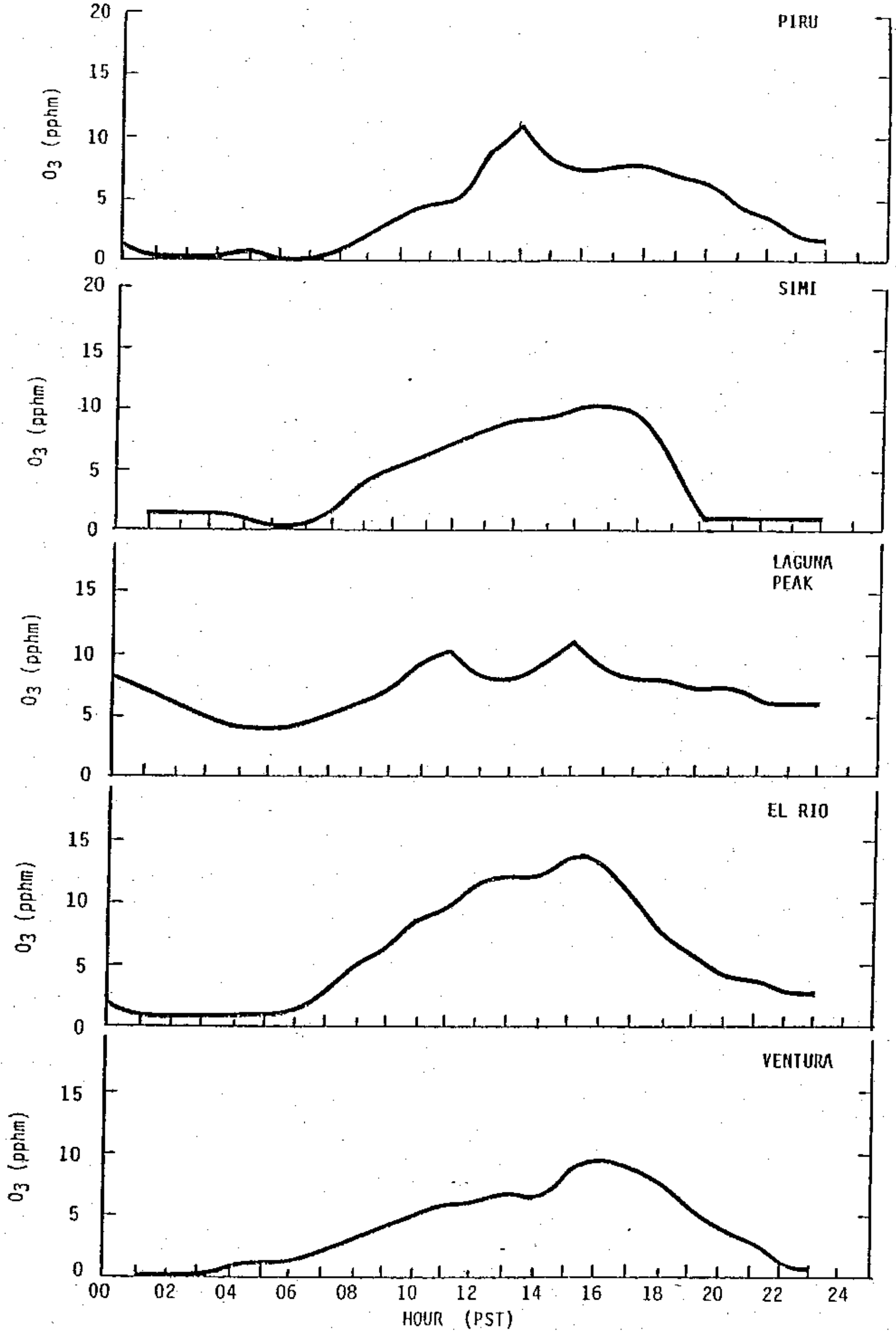

Figure 3-3. Hourly Average Ozone Concentrations for 11 September 1983.

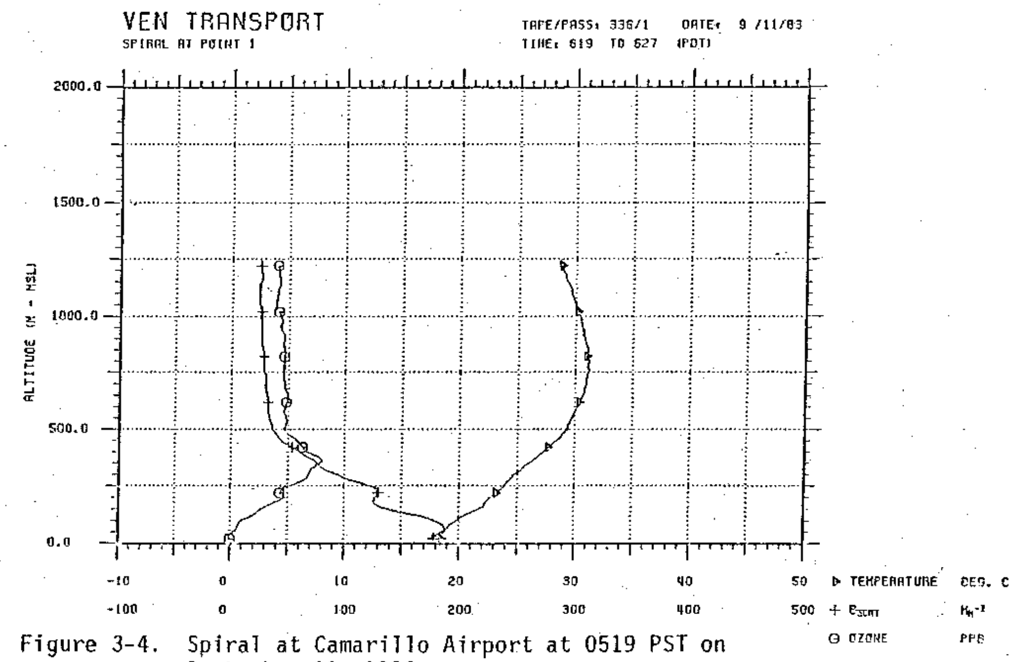

Figure 3-4. Spiral at Camarillo Airport at 0519 PST on September 11, 1983.

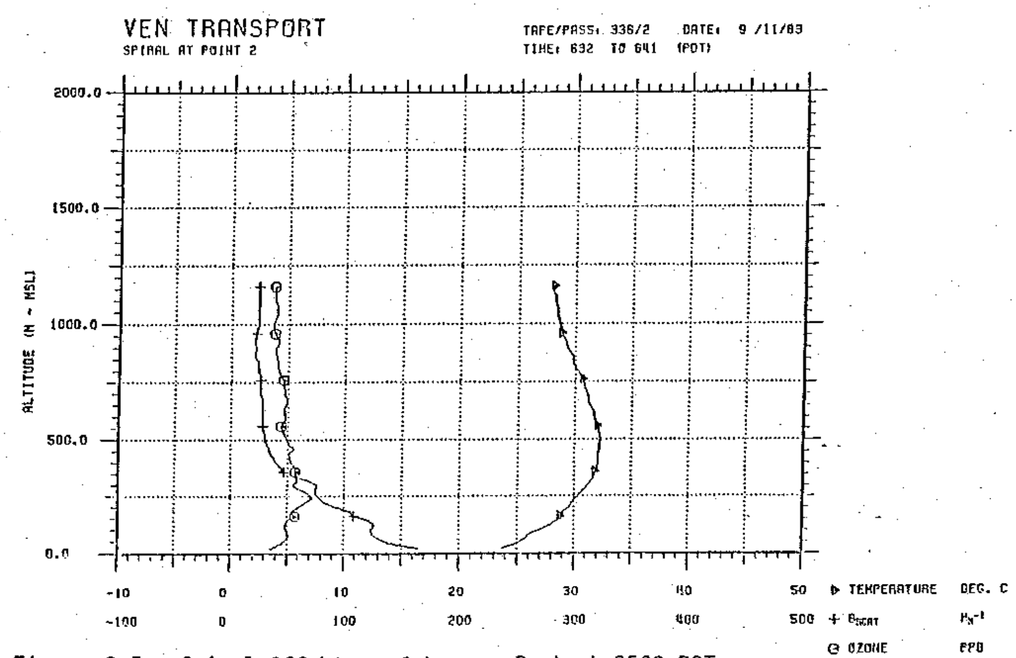

Figure 3-5. Spiral Offshore of Laguna Peak at 0532 PST on September 11, 1983.

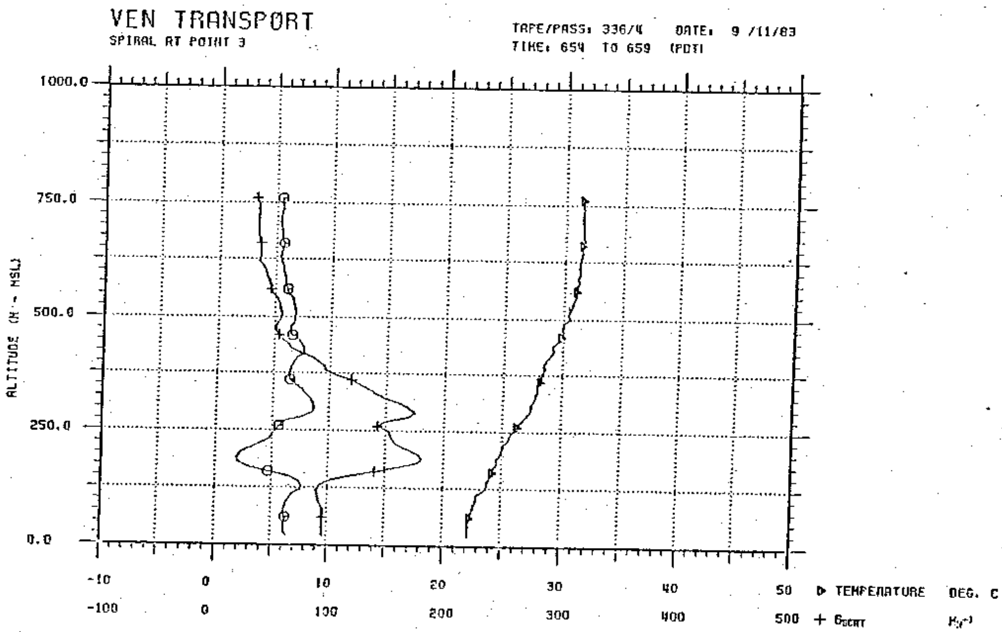

Figure 3-6. Spiral about 10 Miles South of Pt. Mugu at 0554 PST on September 11, 1983.

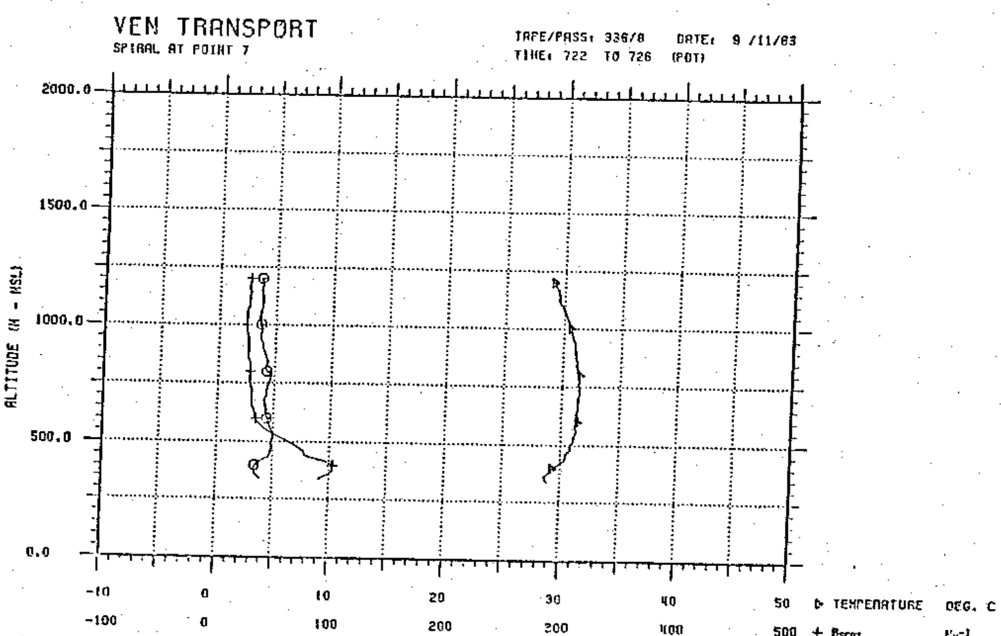

Figure 3-7. Spiral at Westlake Reservoir at 0622 PST on September 11, 1983.

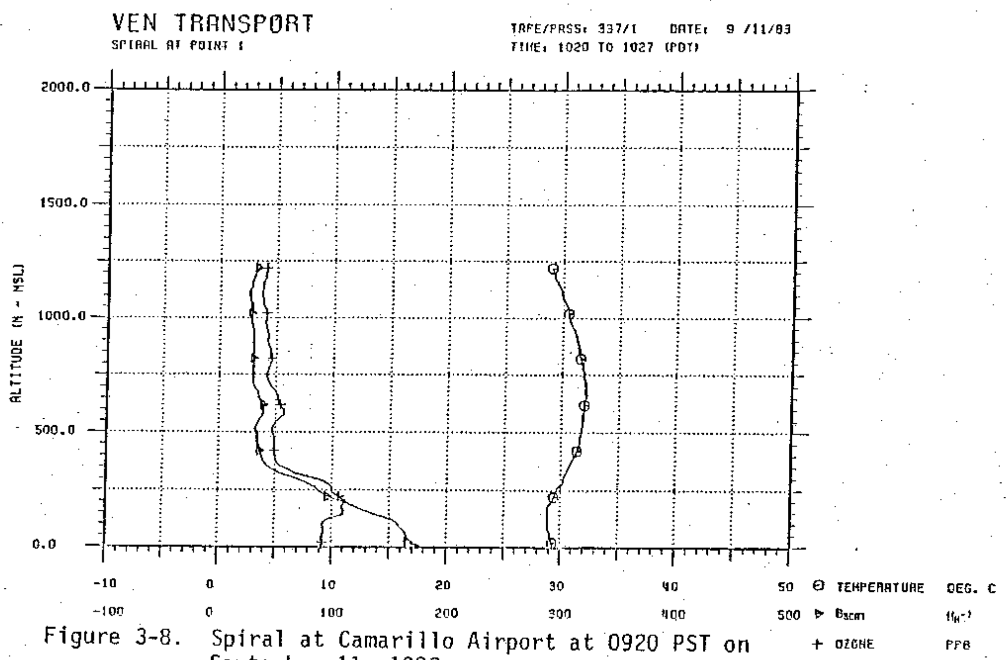

Figure 3-8. Spiral at Camarillo Airport at 0920 PST on September 11, 1983.

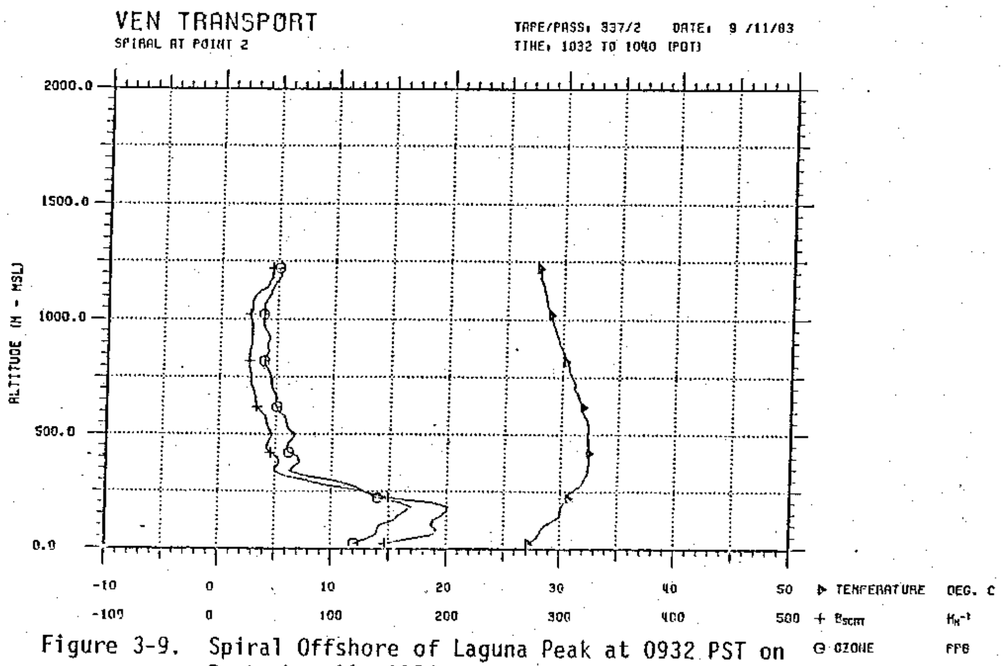

Figure 3-9. Spiral Offshore of Laguna Peak at 0932 PST on September 11, 1983.

Figure 3-10 shows an aircraft traverse between the two offshore sounding locations from 0941-0947 PST at a level of 168 m msl, within the ozone layer. The traverse shows ozone levels of 15 pphm or more along the entire traverse. Concentrations of 17-18 pphm were observed near the end of the traverse. Figure 3-11 shows the sounding taken at the end of the traverse. A more extensive ozone layer was present with a base of 100 m msl and a peak ozone concentration of 17 pphm. Figures 3-9 and 3-11 indicate that the ozone layer aloft did not extend to the surface and was prevented from mixing downward by the temperature inversion. In view of the southeasterly winds observed at Loyola-Marymount and the relatively high ozone concentrations observed offshore, it is suggested that this pollutant material originated in the South Coast Air Basin and was transported to the sounding locations by the southeasterly winds.

Figures 3-12 and 3-13 show soundings made in the late morning at Westlake Reservoir and Simi. There are no indications of ozone increases at any level in these soundings. Simi reported a surface ozone concentration of 6 pphm for the hour during which the Simi sounding was made. Although Camarillo and the offshore locations had experienced increases in ozone since the early morning flight, none appeared at the inland areas.

Figures 3-14 and 3-15 show the soundings at Camarillo and at the near-shore offshore location during mid-afternoon. The Camarillo sounding represents approximately the time when high surface ozone concentrations were observed in the coastal plain of Ventura County. The mixed layer at Camarillo had increased in depth to slightly over 250 m msl which was sufficient to incorporate all of the ozone layer aloft which was observed over the water. Surface heating over the land thus resulted in the elimination of the shallow, unmixed layer over the water and in the uniformly mixed layer shown in Figure 3-14. Offshore the layer continued with a depth of 250 m msl, but with a peak concentration which had increased to 25 pphm.

Figure 3-16 is a traverse between the two offshore sounding locations at 152 m msl. The data indicate that the ozone layer offshore was extensive, decreasing somewhat near the end of the traverse. This is further illustrated in Figure 3-17 which shows the sounding at the end of the traverse for which the peak ozone concentration observed was only 21 pphm at 150 m msl. The data suggest that the highest concentrations offshore were somewhat closer to the coast than was observed in the late morning.

Figures 3-18 and 3-19 show the soundings made at Westlake Reservoir and Simi during the mid-afternoon flight. These soundings were made prior to the arrival of the second ozone peak identified in Figure 3-3. Ozone concentrations in the low layers had increased from the late morning sounding and appear to be representative of conditions near the first ozone peak (Figure 3-3).

The assumed trajectory of the offshore ozone cloud is summarized in Figure 3-20. This trajectory has been estimated for parcels arriving at El Rio at the time of maximum surface concentration. Elevated and surface trajectories are contrasted in the figure. Because of the shallow nature of the ozone layer, supporting winds for the trajectory from the offshore locations to Camarillo do not exist. The trajectory has been constructed under the assumption that the offshore ozone concentrations are the only likely source of the later ozone peak which was observed in the Ventura coastal plain as well as inland.

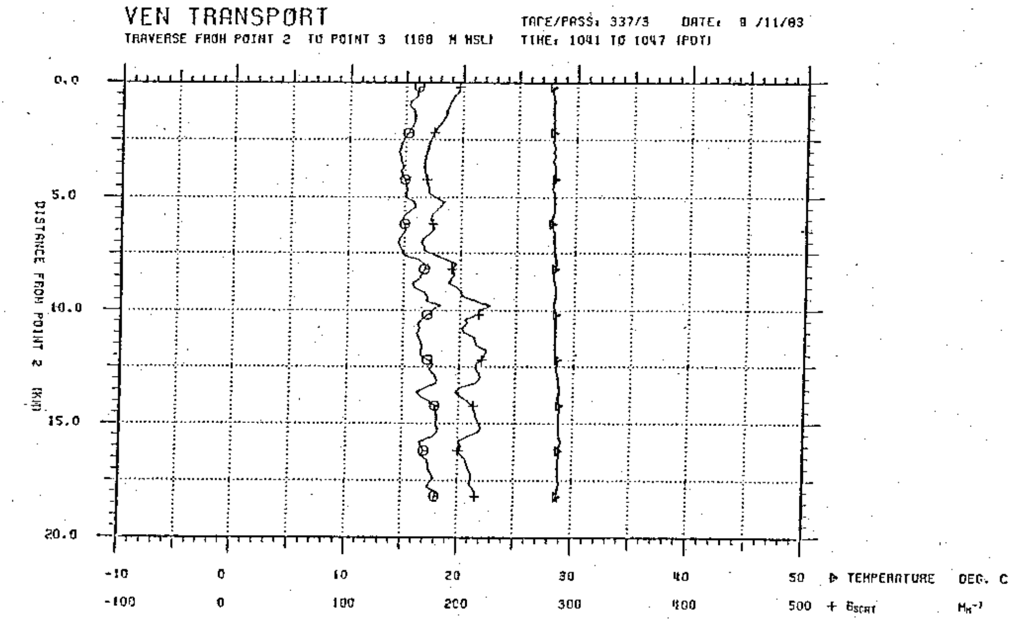

Figure 3-10. Traverse from Shoreline near Laguna Peak to 10 Miles South of Pt. Mugu at 0941 PST on September 11, 1983.

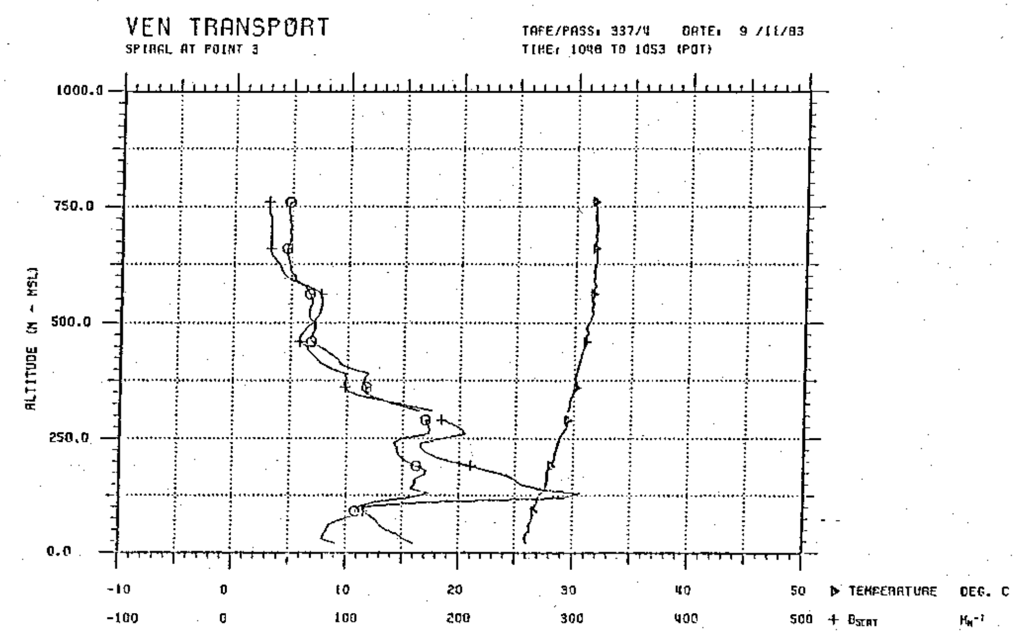

Figure 3-11. Spiral at 10 Miles South of Pt. Mugu at 0948 PST on September 11, 1983.

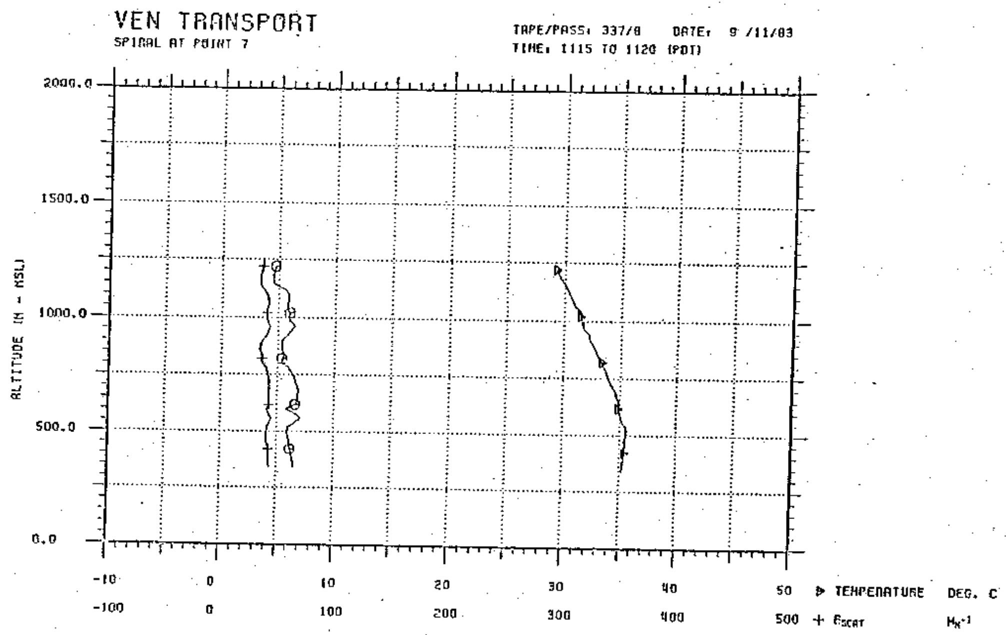

Figure 3-12. Spiral at Westlake Reservoir at 1015 PST on September 11, 1983.

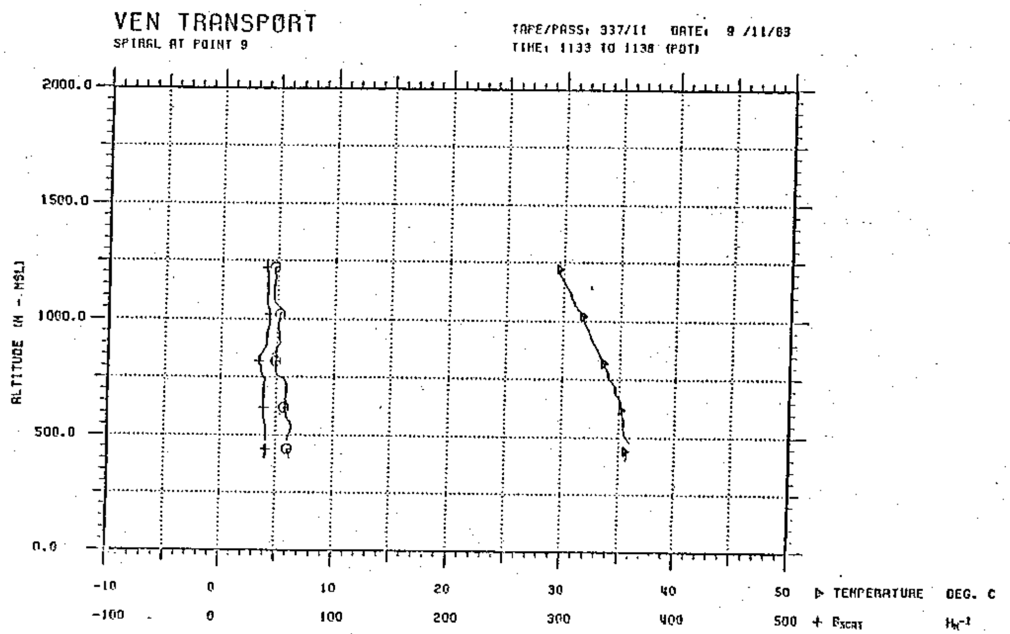

Figure 3-13. Spiral at Simi at 1033 PST on September 11, 1983.

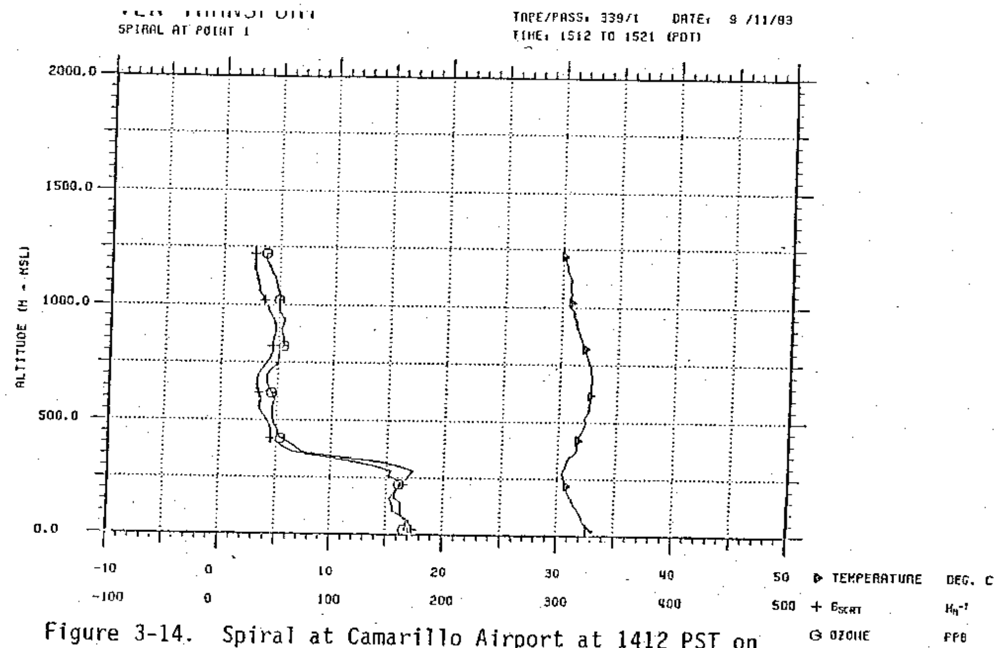

Figure 3-14. Spiral at Camarillo Airport at 1412 PST on September 11, 1983.

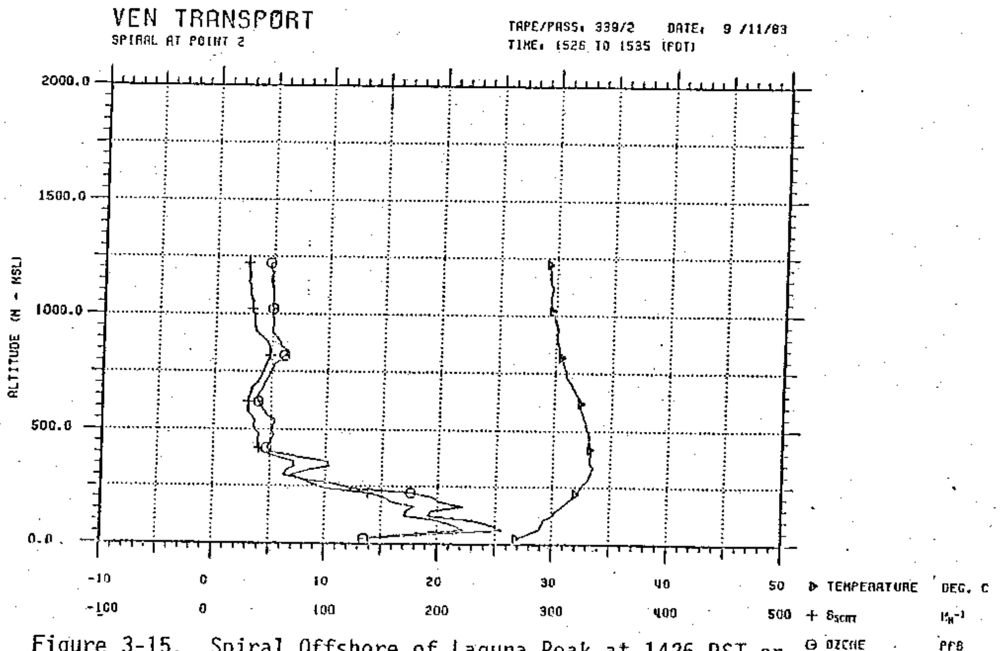

Figure 3-15. Spiral Offshore of Laguna Peak at 1426 PST on September 11, 1983.

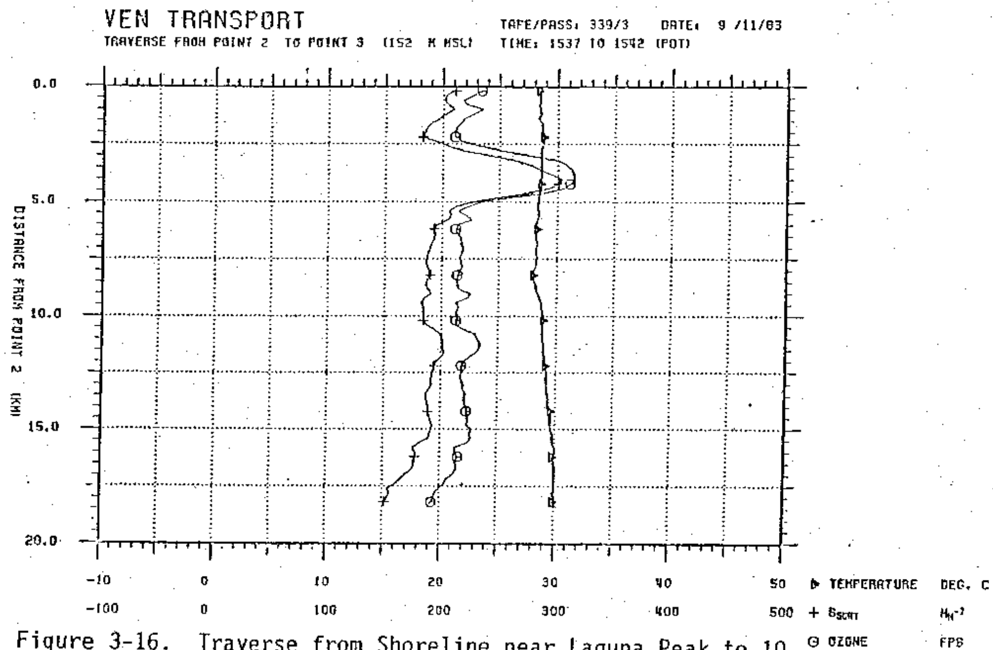

Figure 3-16. Traverse from Shoreline near Laguna Peak to 10 Miles South of Pt. Mugu at 1437 PST on September 11, 1983.

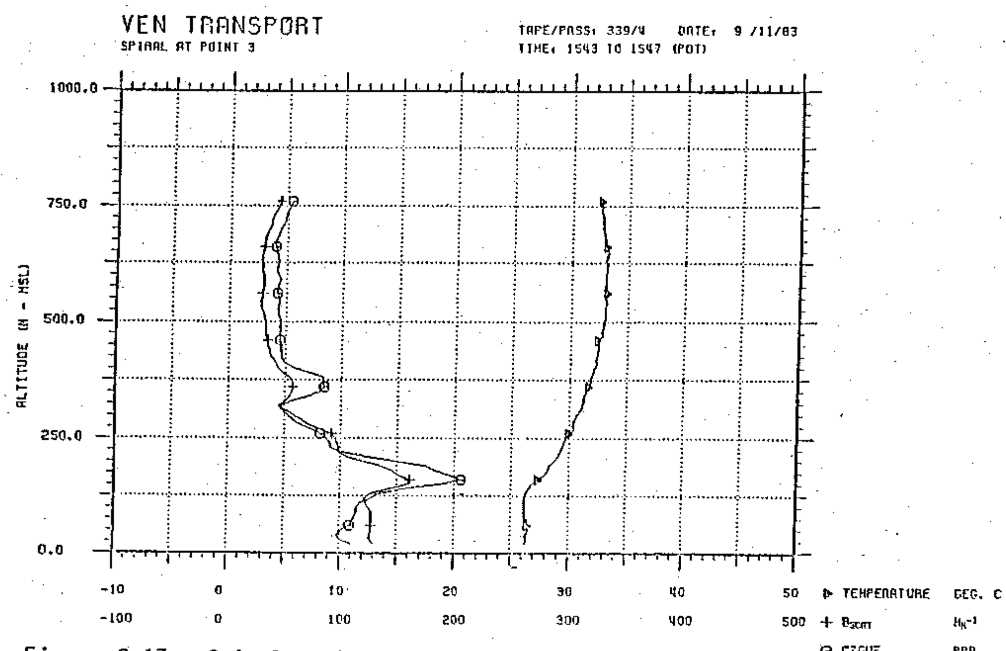

Figure 3-17. Spiral at 10 Miles South of Pt. Mugu at 1443 PST on September 11, 1983.

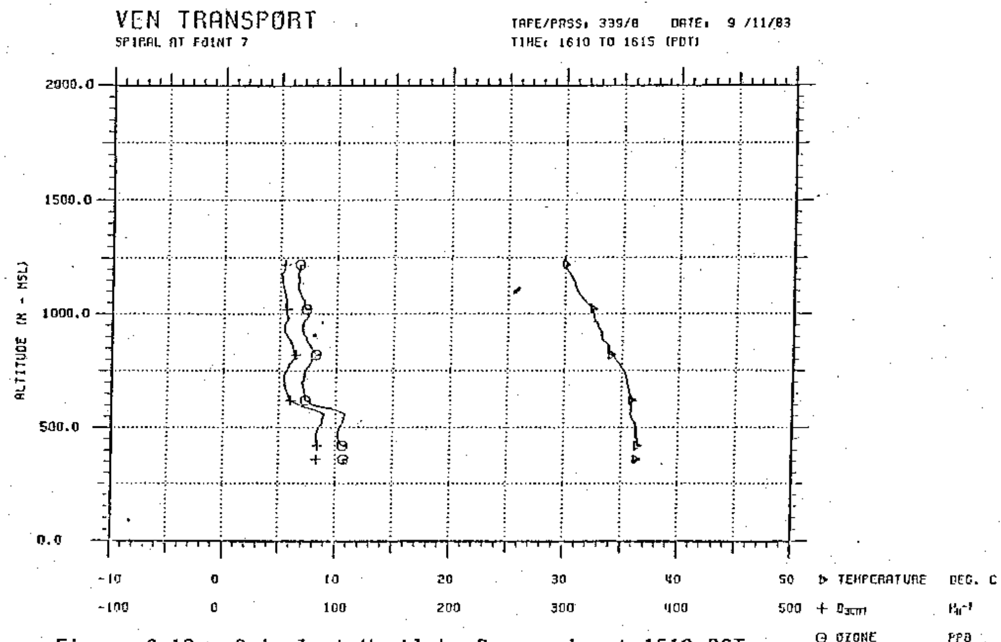

Figure 3-18. Spiral at Westlake Reservoir at 1510 PST on September 11, 1983.

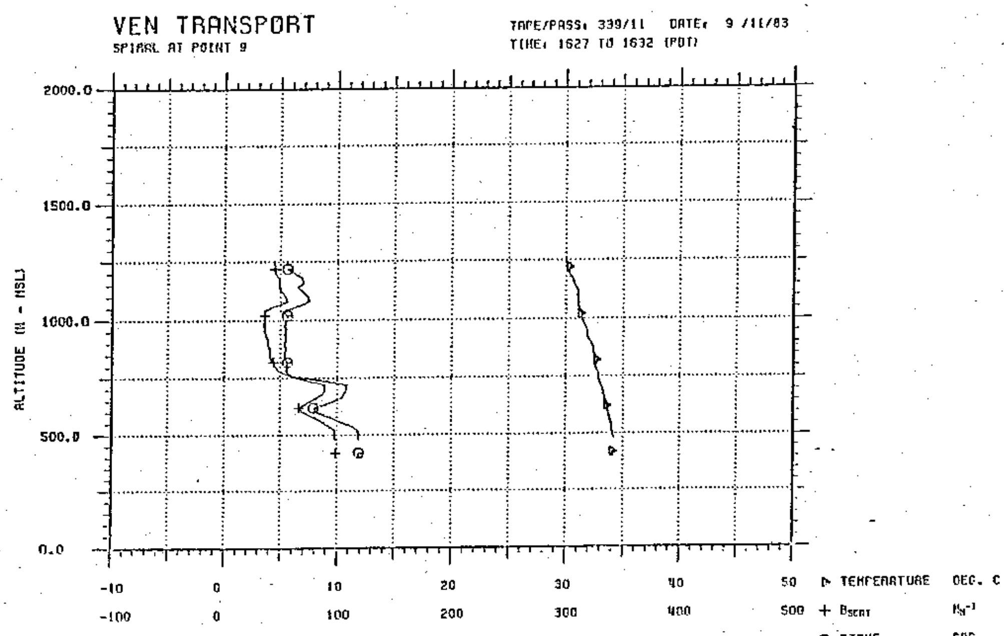

Figure 3-19. Spiral at Simi at 1527 PST on September 11, 1983.

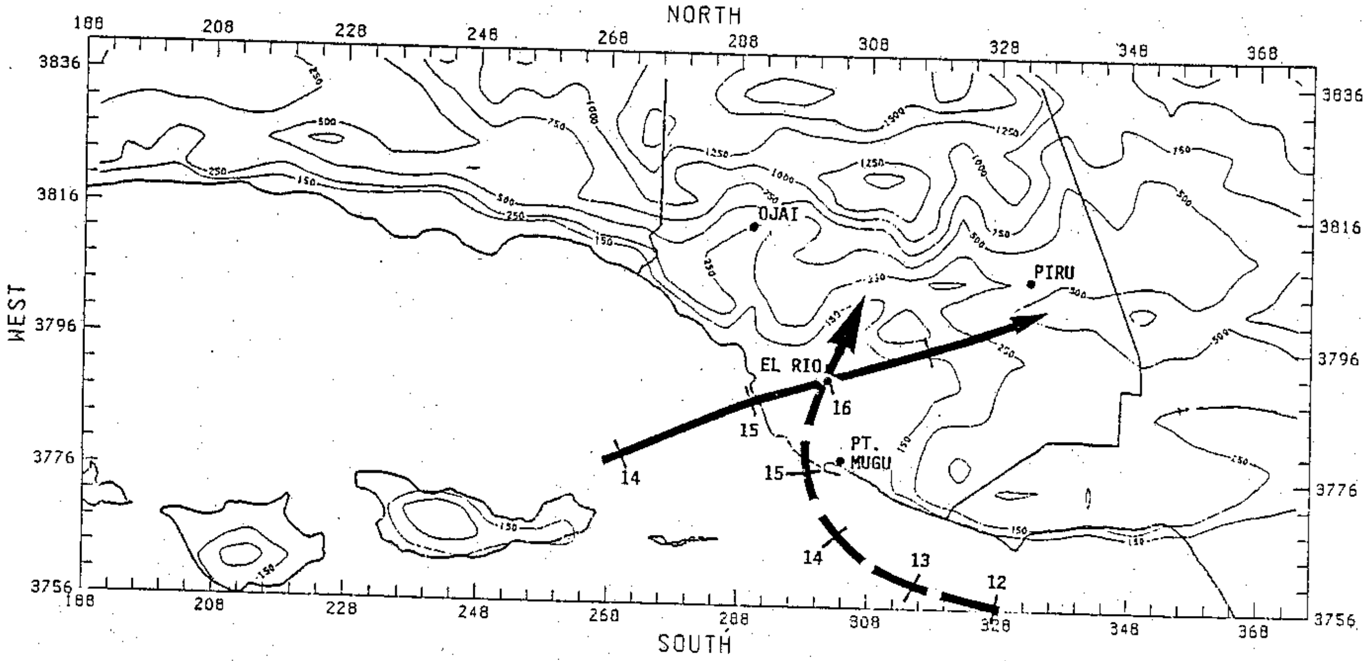

Figure 3-20. Approximate Surface and Elevated Trajectories Arriving at El Rio During the Hour of Maximum Ozone on September 11, 1983. (Solid line is surface level trajectory and dashed line is elevated trajectory. Hours shown are PST.)

Goleta and Santa Barbara experienced peak ozone concentrations of 13 and 12 pphm, respectively, on September 11th but with only one peak. In view of the westerly winds throughout the area, it is not suggested that these concentrations were associated with the ozone layer observed offshore to the south of Ventura. However, they may have been associated with offshore concentrations of pollutants with more local origins.

Surface winds at Santa Barbara and Platform Hondo were easterly to northeasterly throughout the night of September 10th-11th from 2000 to 0800 PST. Thereafter, southwesterly winds prevailed. It is proposed that pollutants existing along the coastal strip on the 10th were carried offshore during the night, were confined to a shallow layer over the water, and were returned to the coast by the sea breeze during the day.

This suggested mechanism represents an internal recycling of pollutants from one day to the next within the South Central Coast Air Basin. It is reasonable to question whether such a mechanism also operates along the Ventura Coast. Observed offshore winds during the night of the 10th along the Ventura Coast, however, do not appear to have been strong enough to carry pollutants very far offshore. Thus, the late ozone peak observed in the Ventura County area has been attributed to transport into the South Central Coast Air Basin from the outside.

3.3.2 September 12, 1983

3.3.2.1 General Meteorology

The high pressure in the northwest continued and merged with a major high pressure area in western Canada (Figure 3-21). The surface thermal low pressure area existed along the California coast, slightly farther to the west than was the case on the 11th. Surface pressure gradients from the inland areas were directed toward the coast from Reno to Las Vegas. High pressure aloft (500 mb) was centered in western Arizona and contributed to subsidence and warm temperatures aloft throughout southern California.

Skies were clear at Santa Barbara throughout the day. Low scattered to broken clouds developed in the Pt. Mugu area about 1400 PST and lasted through 1900 PST. Visibilities at Pt. Mugu decreased to about 1/2 mile by about 1700 PST, increasing during the evening. The low clouds extended as far inland as Oxnard for several hours between 1600 and 1900 PST.

Significant meteorological parameters for September 12, 1983 are summarized in Table 3-10.

The offshore wind flow condition continued on September 12th with an 850 mb temperature one degree warmer than on the 11th. The offshore pressure gradient in central California was somewhat greater than on the 11th and was associated with a more westerly position for the surface low pressure trough along the coast. Inversion bases at Pt. Mugu were quite low and south-southeasterly winds prevailed at 1000 m msl within the temperature inversion.

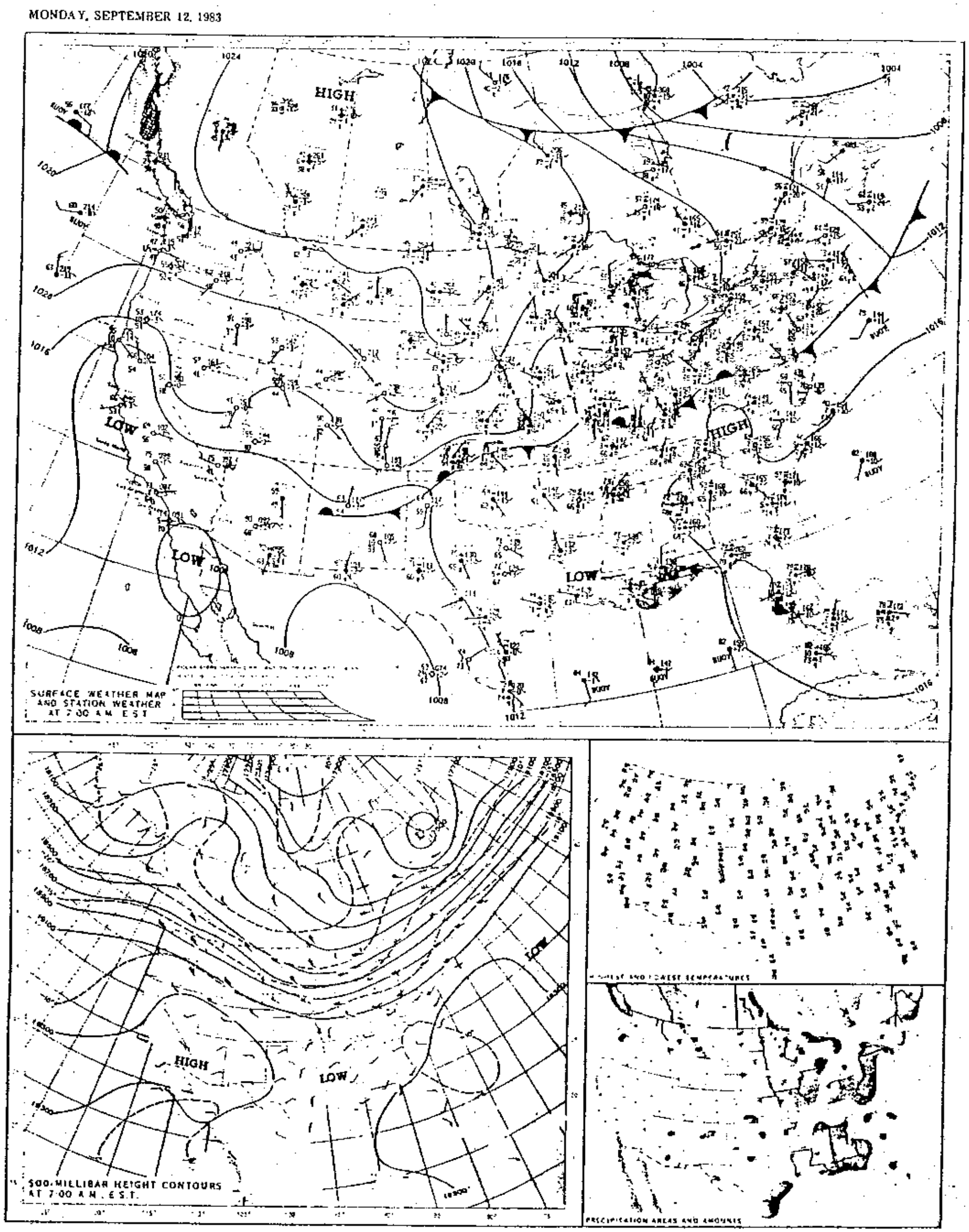

Figure 3-21. Surface and 500 mb Synoptic Weather Maps for 12 September 1983 at 0400 PST.

Table 3-10. Meteorological Parameters for September 12, 1983

	9/12/83	Long Term Average*
850 mb temperature at 0400 PST at Vandenberg AFB	25.5°C	18.1°C
Surface Pressure Gradients (0400 PST)		
San Francisco-Reno	-6.5 mb	-1.2 mb
Los Angeles-Bakersfield	-1.2	-0.1
Los Angeles-Las Vegas	-1.0	1.6
Inversion Base		
Pt. Mugu (0255 PST)	Surface	
Pt. Mugu (0847 PST)	Surface	
Pt. Mugu (1505 PST)	180 m msl	
Upper Winds (1000 m msl)		
Pt. Mugu (0255 PST)	304°/2.5 m/s	
Pt. Mugu (0847 PST)	132°/2	
Pt. Mugu (1505 PST)	180°/1	

*average September values (1980-83).

3.3.2.2 Transport Winds

Table 3-11 gives the surface wind observations for several locations on September 12th.

Table 3-11. Surface Transport Wind Summary for September 12, 1983

Time (PST)	eLaguna Peak (deg./m/s)	Platform Grace (deg./m/s)	Pt. Mugu (deg./m/s)	Santa Barbara (deg./m/s)
0600	120/5	109/3.1	060/1	060/3
0800	110/3	129/3.6	030/1	050/2
1000	150/6	143/5.3	150/6	140/5
1200	140/3	138/4.8	150/6	150/5
1400	120/9	160/3.0	190/5	150/6
1600	140/8	138/3.7	190/4	200/5
1800	130/7	133/2.5	170/3	120/2
2000	090/4	155/1.0	calm	calm
2200	050/2	100/3.0	150/1	090/2

Wind directions observed at Simi by the doppler acoustic sounder on September 12th are given in Table 3-12.

Table 3-12. Doppler Acoustic Sounder Wind Directions at Simi at 1000 m msl for September 12, 1983

Time (PST)	Wind (deg.)	Time (PST)	Wind (deg.)
0800	056	1600	M
1000	135	1800	M
1200	105	2000	M
1400	M	2200	M

Wind flow patterns on September 12th indicate a southeasterly flow throughout the area during the entire day. There was little sign of the customary sea breeze except for a slight influence for a few hours in mid-afternoon at Pt. Mugu and Santa Barbara. From the available acoustic sounder data, the upper wind flow at Simi was also from the southeast at all levels to 1000 m msl through 1200 PST when a system malfunction occurred.

The wind patterns on September 12th were very conducive to the transport of pollutants from the South Coast Air Basin into the South Central Coast Basin.

3.3.2.3 Mixing Heights

Mixing heights as determined from aircraft soundings on September 12, 1983 are shown in Table 3-13.

Table 3-13. Mixing Heights from Aircraft Soundings on September 12, 1983

	Time (PST)	Mixing Depth (m agl)
Camarillo (sfc. elev. 25 m)		
	0522	75
	0914	225
	1427	150
Pt. 2 (3 mi SSW Laguna Peak)		
	0534	150
	0927	150
	1442	(350) top of stratus
Pt. 3 (13 mi SSW Laguna Peak)		
	0944	100
	1457	stratus
Westlake Reservoir (sfc. elev. 305 m)		
	0618	200
	1012	400
	1523	400
Simi (sfc. elev. 335 m)		
	0639	310
	1031	360
	1541	360

Mixing heights continued low on September 12th but increased slightly from the values observed on September 11th. Inland mixing heights remained relatively low compared to average afternoon conditions.

3.3.2.4 Regional Ozone Concentrations

Maximum ozone concentrations for September 12th in the South Central Coast Air Basin are presented in Table 3-14 together with the time of the maximum concentration and the observed wind at the time of the maximum.

Table 3-14. Maximum Ozone Concentrations on September 12, 1983

Location	Maximum Concentration (pphm)	Time of Maximum (PST)	Wind (deg./m/s)
Ojai	14	15	220/3
Piru	17	12-13	245/M
Simi	23	13	139/4
Thousand Oaks	18	12	
Rocketdyne	24	13	148/4
El Rio	-	-	
Laguna Peak	13	11-12	145/4
Ventura	15	12	200/5
La Conchita	10	12	
Santa Barbara	11	12	150/5
Goleta	13	13	
El Capitan Beach	13	14-16	

Ozone exceedances occurred at most reporting stations in the South Central Coast Air Basin on September 12th. Highest values occurred near the Simi Hills but the coastal areas as far west as El Capitan Beach also recorded high ozone values.

3.3.2.5 Transport Analysis

Figure 3-22 shows the hourly ozone concentrations for September 12th for several locations in Ventura County. The earliest ozone peak occurred at Laguna Peak and the latest at Ojai. A comparison of the times of maximum ozone suggests transport from the southeast with the Ventura and Piru maximum times falling between Laguna Peak and Ojai. Table 3-14, however, gave a time of maximum ozone occurrence of 1200 PST at both Santa Barbara and Ventura. The flow patterns and the timing of the ozone maxima suggest that the ozone peaks at Santa Barbara and Ventura on September 12th resulted from different scenarios. The Santa Barbara peak (Table 3-14) was seen to move westward past Goleta and El Capitan Beach in the few hours after 1200 PST while the Ventura peak traveled inland toward Ojai. The transport evidence derived from the peak ozone times, therefore, suggests southeasterly transport in both the Ventura and Santa Barbara areas, but the two areas did not appear to be under the influence of ozone from the same source region.

Figures 3-23 and 3-24 present the early morning aircraft soundings at Camarillo and 3 mi SSW of Laguna Peak (Point 2). Although the Camarillo ozone

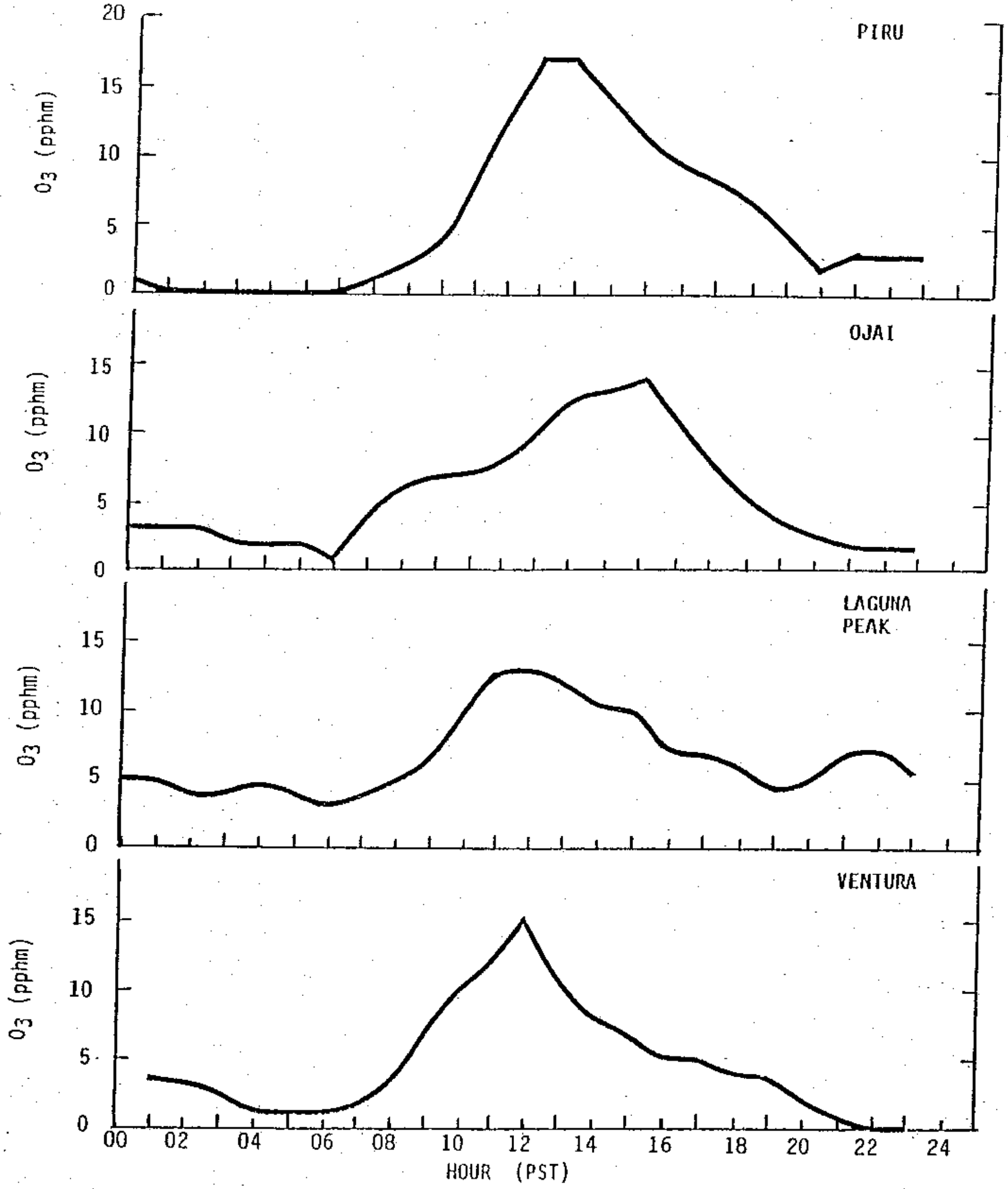

Figure 3-22. Hourly Average Ozone Concentrations for 12 September 1983.

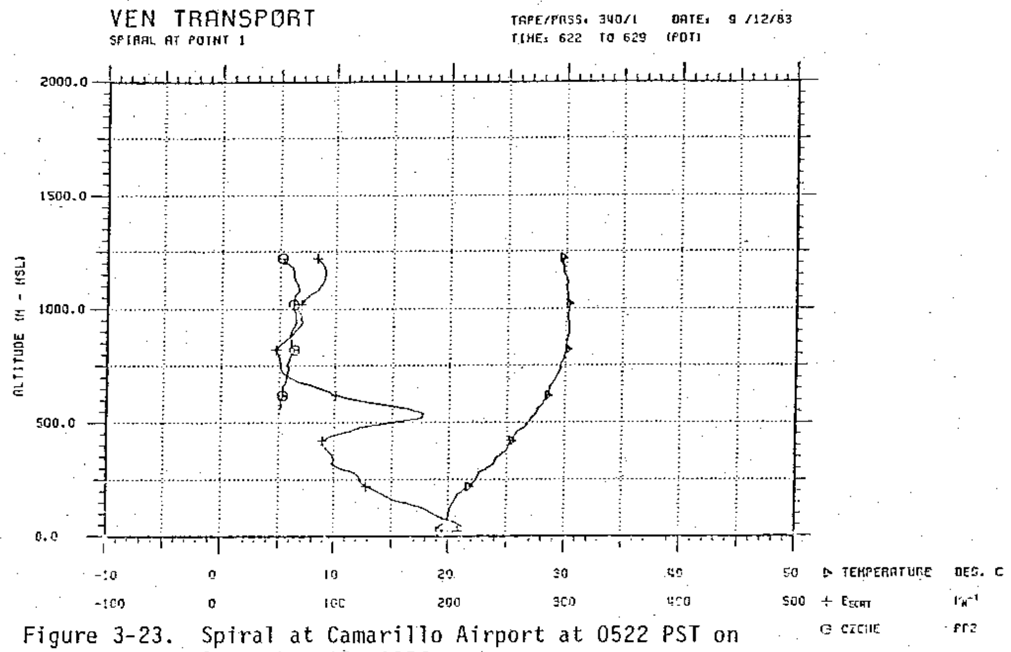

Figure 3-23. Spiral at Camarillo Airport at 0522 PST on September 12, 1983.

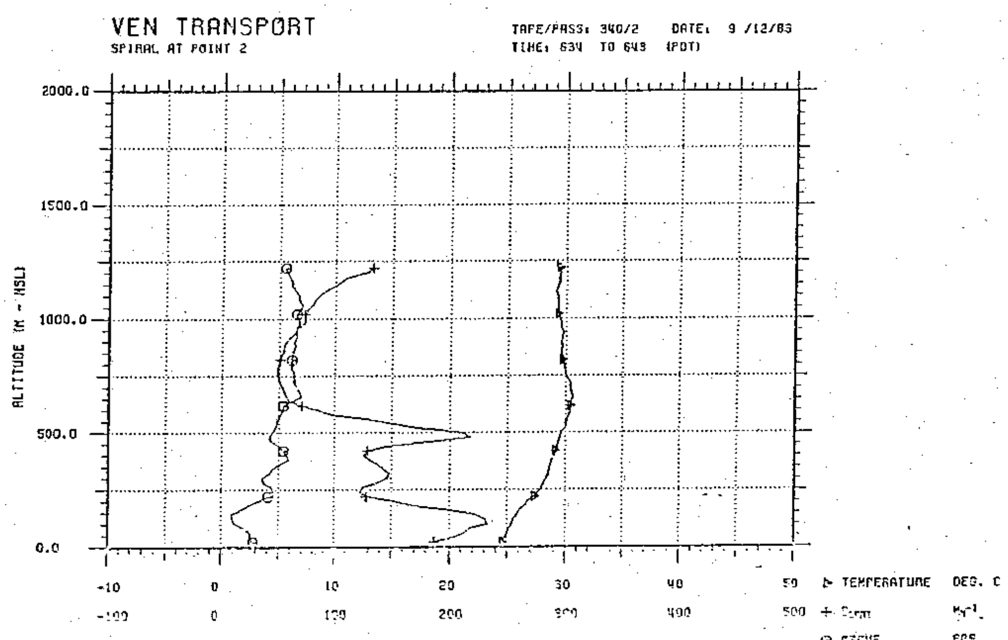

Figure 3-24. Spiral Offshore of Laguna Peak at 0534 PST on September 12, 1983.

sounding was incomplete, there was no evidence for ozone concentrations above the normal background levels. These observations were confirmed by the remaining morning soundings at Simi, Westlake Reservoir, and offshore.

By the late morning flight, however, increased ozone concentrations were observed at all locations. Figure 3-25 shows the mid-morning sounding at Camarillo with an elevated layer (peak 14 pphm) between 250 and 650 m msl. As indicated, this layer exists within the temperature inversion. Increased concentrations are indicated at Point 2 (3 mi SSW Laguna Peak) from the surface to 650 m msl in Figure 3-26 and from 200 to 500 m msl at Pt. 3 (13 mi. SSW of Laguna Peak) in Figure 3-27. In both cases, the ozone layers existed within the temperature inversion. Figure 3-28 shows a horizontal traverse between Pts. 2 and 3 at 366 m msl. The data show the sharp edge of the ozone cloud at that level about half-way between the two points.

Inland at Westlake Reservoir and Simi, high ozone concentrations were observed below 700 and 600 m msl, respectively, decreasing to background levels aloft. A more striking profile is shown in Figure 3-29 which was taken slightly offshore of Ventura. A strong layer of ozone existed within the temperature inversion between 250 and 650 m msl with a peak value of about 22 pphm. There is also an indication in the sounding of an additional ozone layer near 750 m msl.

The appearance of this ozone layer aloft between 0900 and 1130 PST, as evidenced by the soundings, coincides with the arrival of surface ozone concentrations at elevated stations in the area. Peak ozone at Laguna Peak occurred at 1100-1200 PST with a southeast wind flow.

Surface conditions at Rocketdyne and Simi are shown in Figure 3-30. In both cases, the peak ozone occurred in a southeasterly flow regime and suggests direct transport into the area from the southeast. For both Piru and Ojai, however, the peak ozone occurred under a southwesterly flow regime. This suggests that the layer aloft mixed downward in these areas after the seabreeze flow had started (0900 PST at both locations).

Figures 3-31 and 3-32 give the aircraft soundings at Camarillo and 3 mi offshore in the mid-afternoon. A distinct mixing layer existed at Camarillo with two ozone layers above the base of the inversion centered at 450 and 750 m msl. Stratus clouds over the water prevented the lower layer ozone peak from being observed at the offshore location but the higher layer (800 m msl) was apparent. The traverse shown Figure 3-33 indicates that the ozone layer at 396 m msl did not extend as far west as found in the mid-morning flight (Figure 3-28). No significant ozone above background was found above the stratus clouds at Point 3 (Figure 3-34).

Figures 3-35 and 3-36 show the aircraft soundings at Westlake Reservoir and Simi for the late afternoon flight. Both soundings show that the elevated layer (700 to 1250 m msl) did not mix downward to the surface at these locations. High ozone levels near the surface of 18-19 pphm, however, were probably strongly influenced by the lower ozone layer.

The flow patterns on September 12th are summarized in Figure 3-37. Upper level trajectories indicate that an extensive ozone layer moved from the southeast into the South Central Coast Air Basin. Surface winds and trajectories in portions of Ventura County indicate that some of the lower

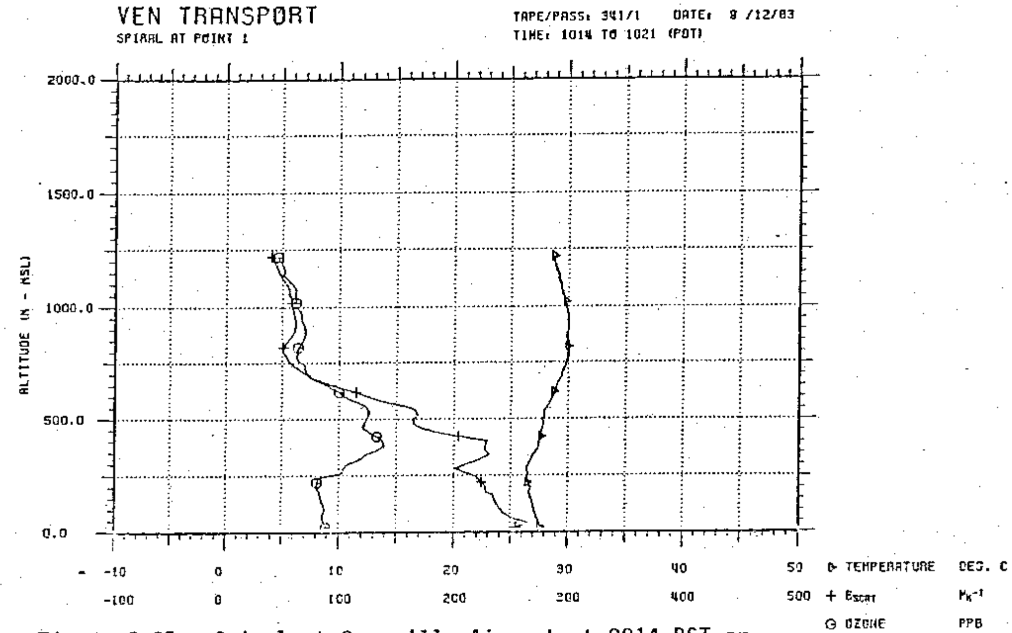

Figure 3-25. Spiral at Camarillo Airport at 0914 PST on September 12, 1983.

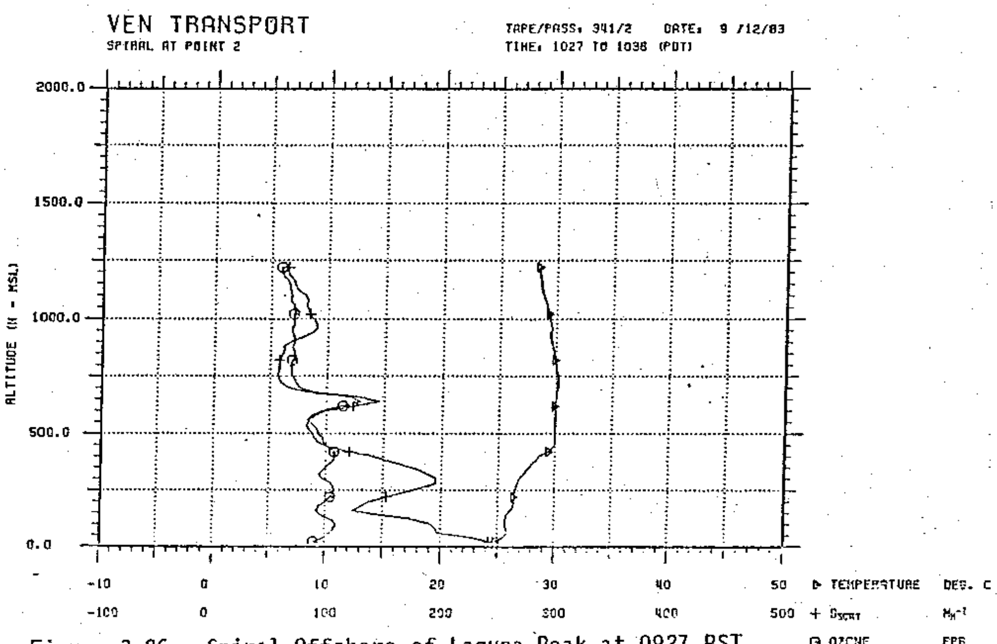

Figure 3-26. Spiral Offshore of Laguna Peak at 0927 PST on September 12, 1983.

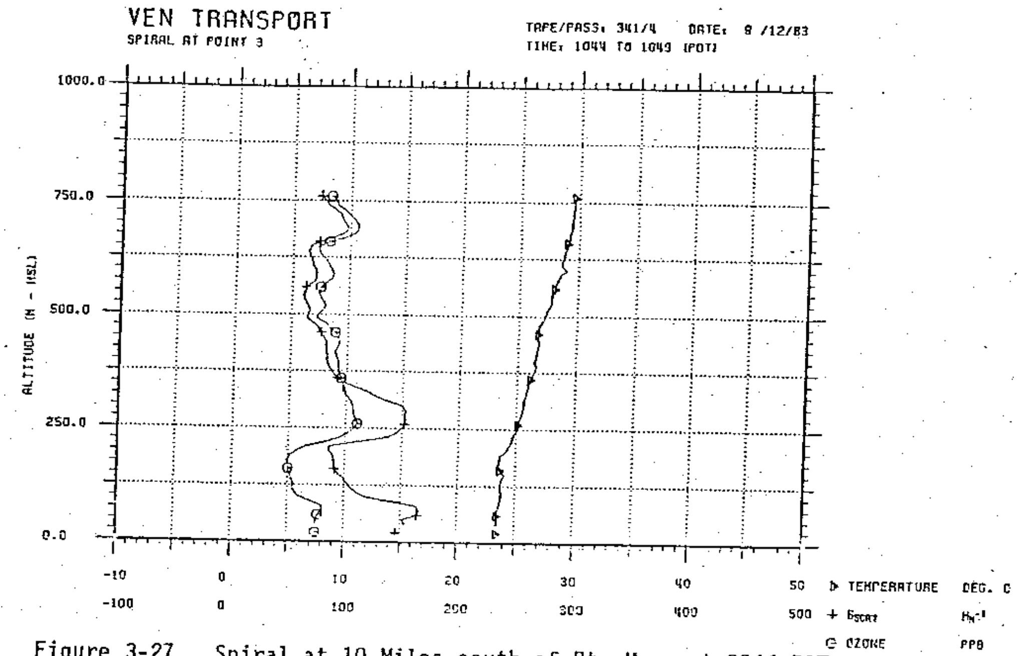

Figure 3-27. Spiral at 10 Miles south of Pt. Mugu at 0944 PST on September 12, 1983.

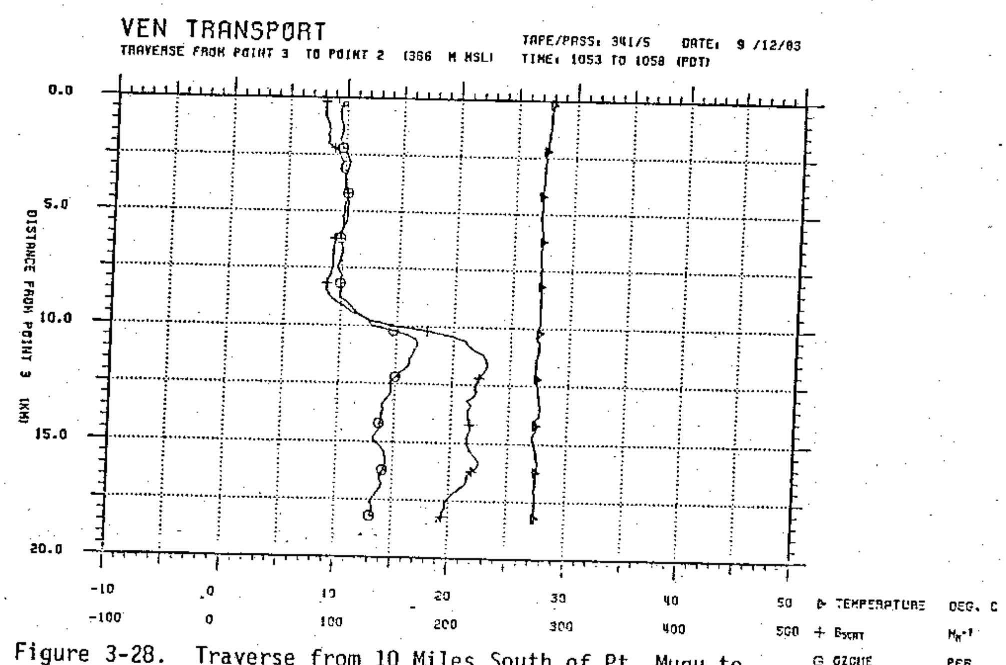

Figure 3-28. Traverse from 10 Miles South of Pt. Mugu to Shoreline near Laguna Peak at 0953 PST on September 12, 1983.

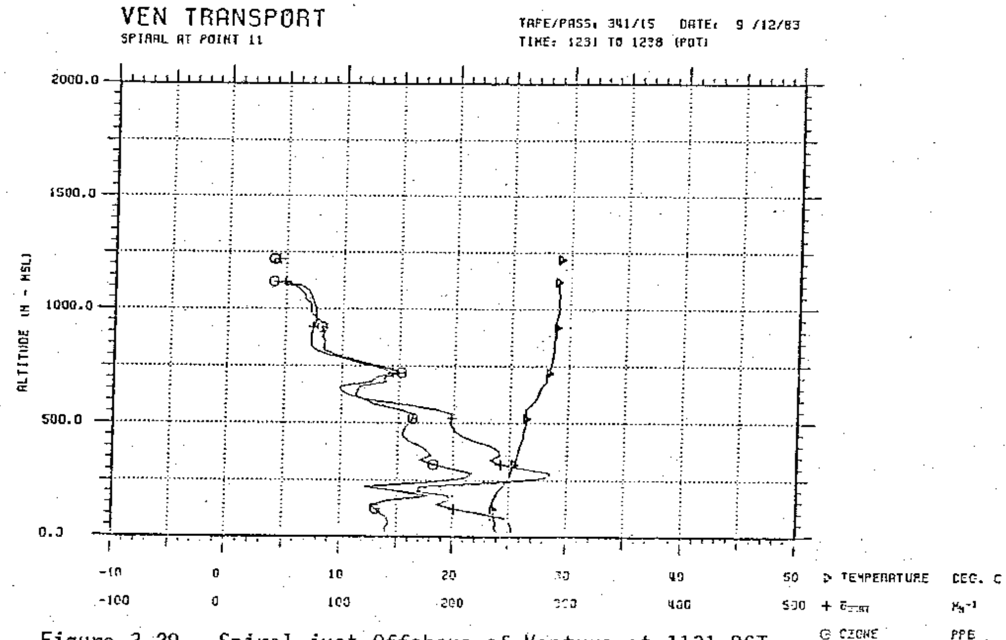

Figure 3-29. Spiral just Offshore of Ventura at 1131 PST on September 12, 1983.

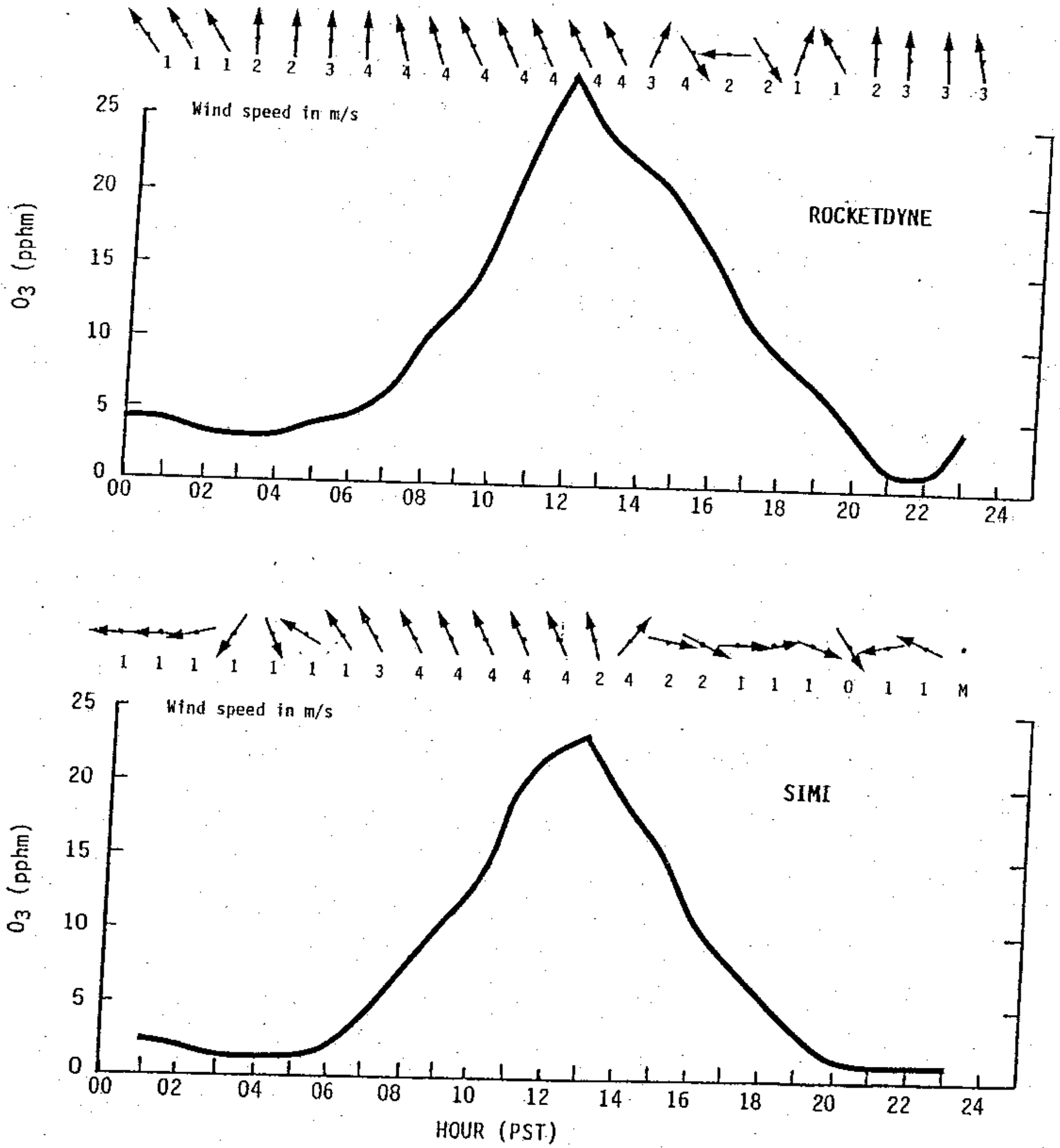

Figure 3-30. Hourly Ozone, Wind Speed and Wind Direction at Rocketdyne and Simi on september 12, 1983.

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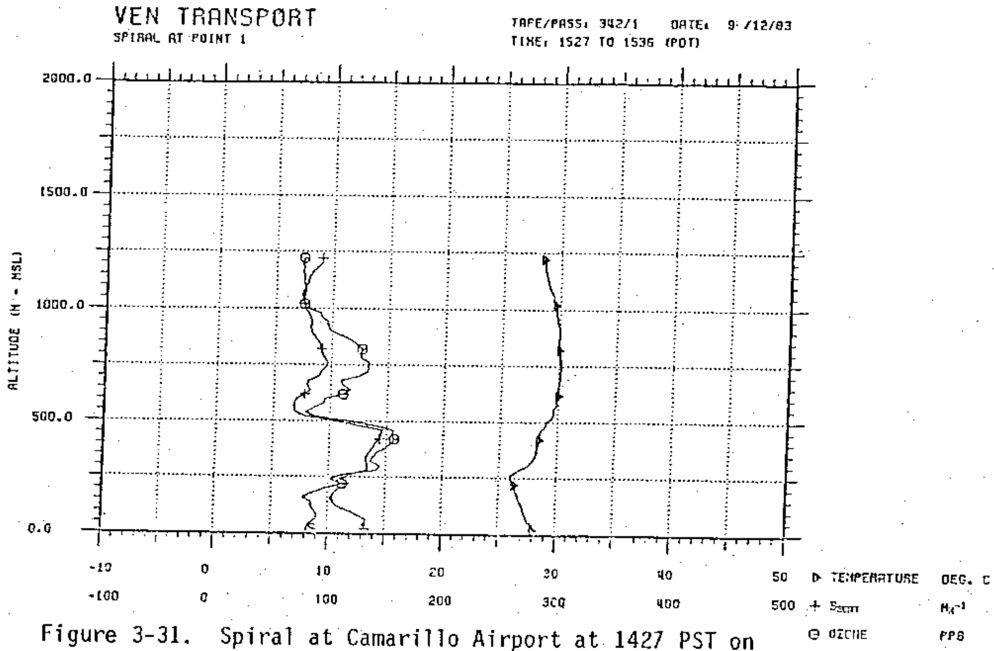

Figure 3-31. Spiral at Camarillo Airport at 1427 PST on September 12, 1983.

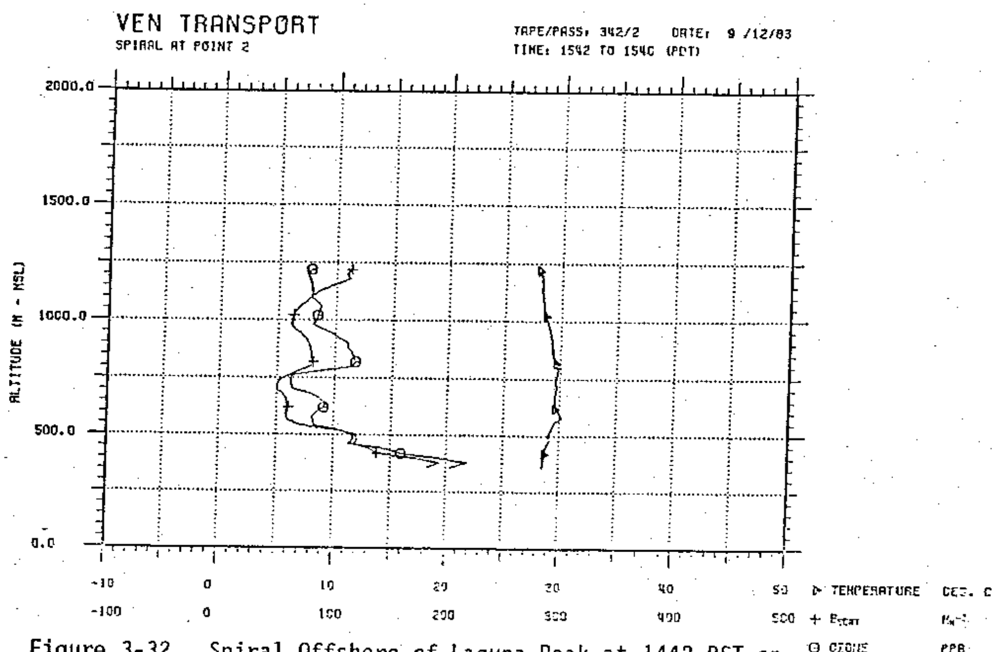

Figure 3-32. Spiral Offshore of Laguna Peak at 1442 PST on September 12, 1983.

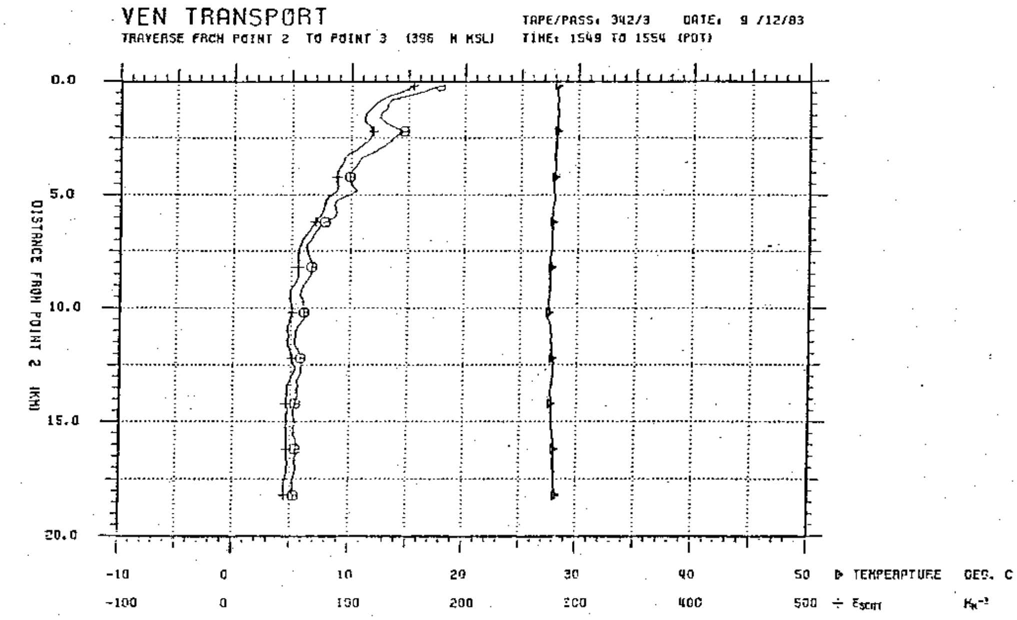

Figure 3-33. Traverse from Shoreline near Laguna Peak to 10 Miles South of Pt. Mugu at 1449 PST on September 12, 1983.

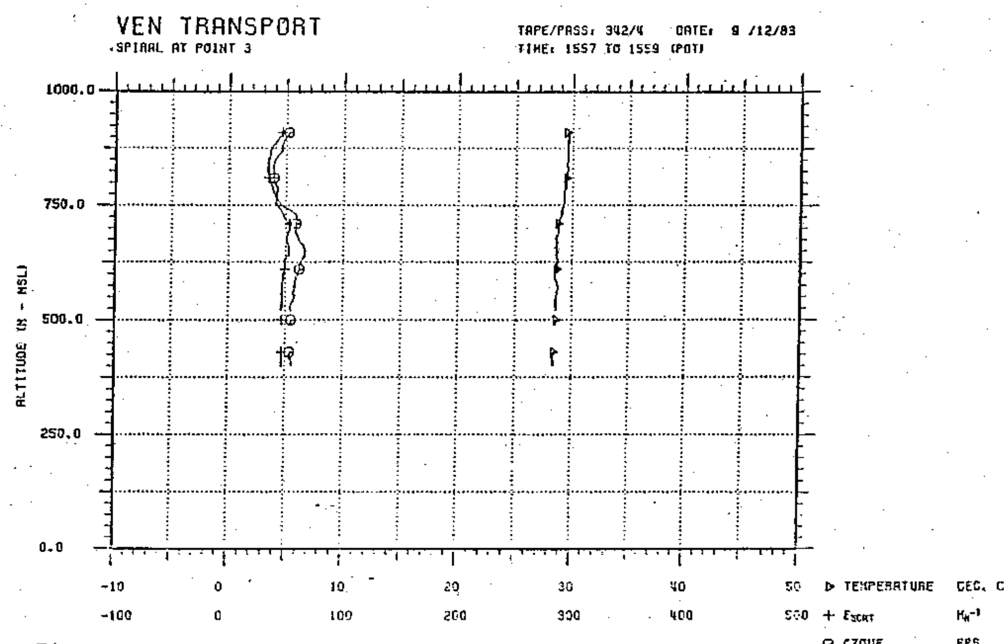

Figure 3-34. Spiral at 10 Miles South of Pt. Mugu at 1447 PST on September 12, 1983.

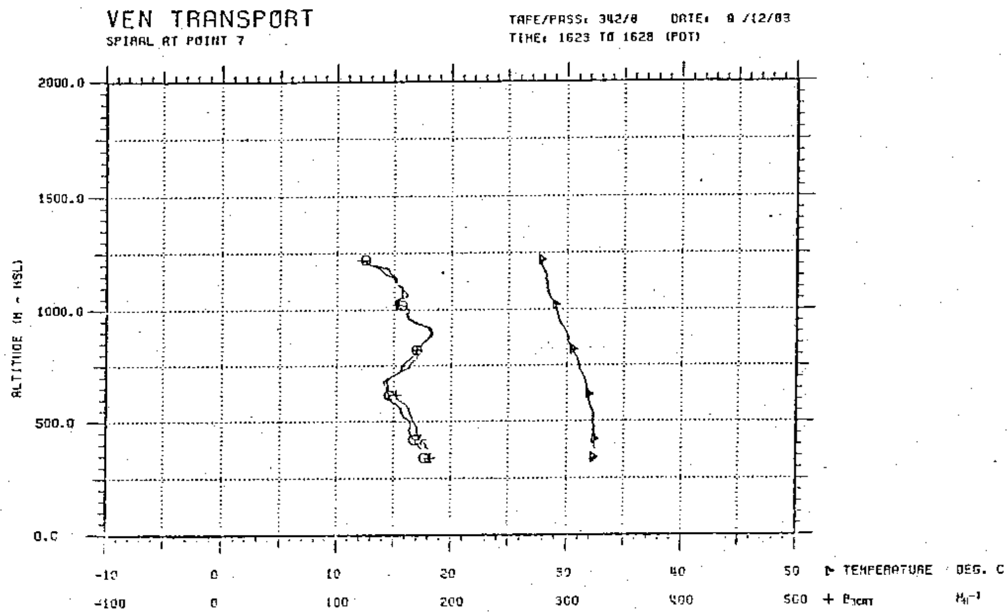

Figure 3-35. Spiral at Westlake Reservoir at 1523 PST on September 12, 1983.

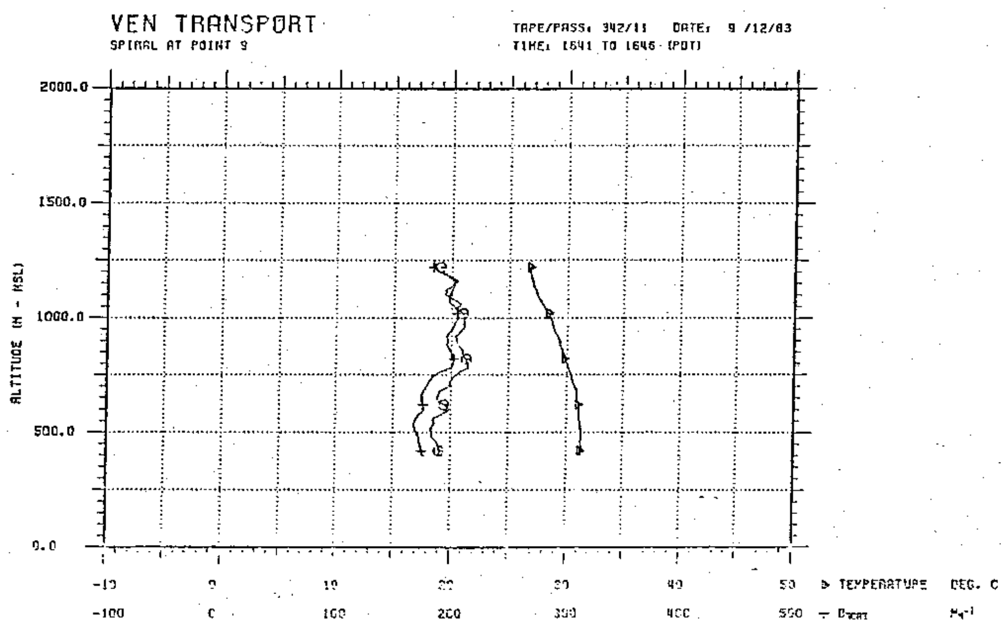

Figure 3-36. Spiral at Simi at 1541 PST on September 12, 1983.

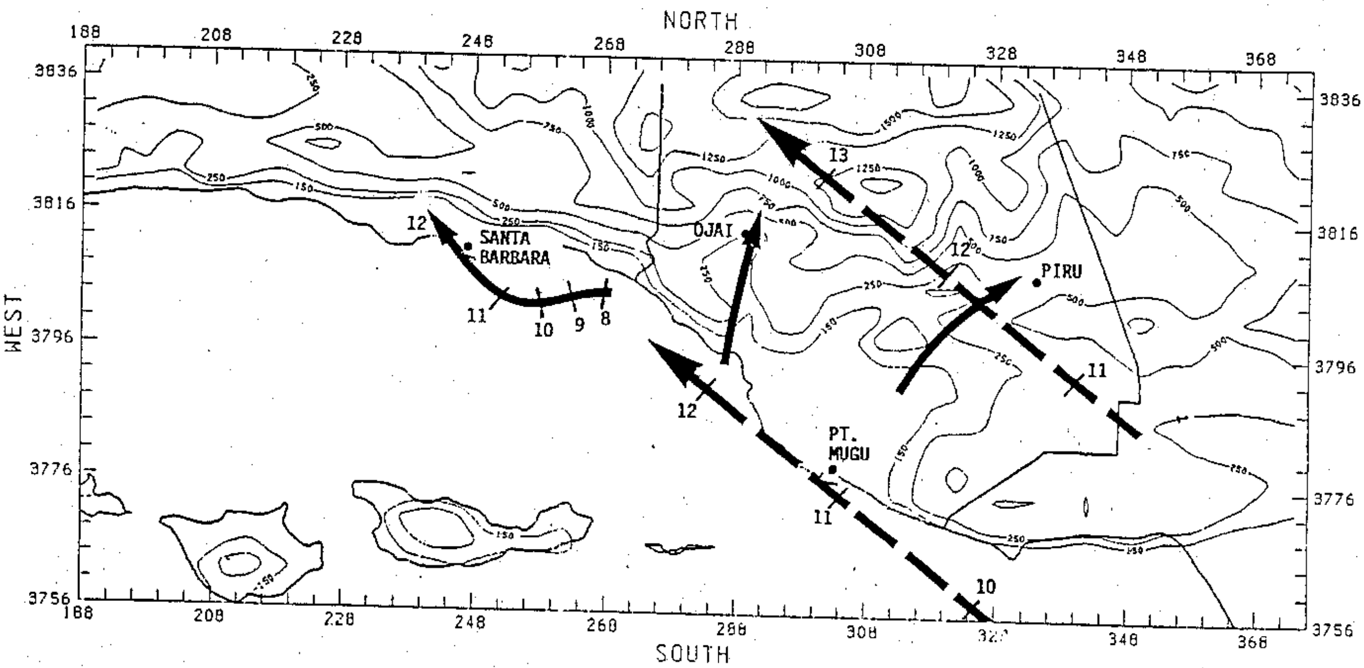

Figure 3-37. Approximate Surface and Elevated Trajectories for September 12, 1983 (Solid lines are surface trajectories and dashed lines are elevated (700m - 1200m) trajectories. Hours shown are PST.)

ozone layer was mixed downward to the surface layers and influenced the surface ozone concentrations. Simi and Rocketdyne, with a southeast wind, were observation stations where the peak concentration could be associated with direct surface transport from the southeast.

In the Santa Barbara area the surface trajectory prior to the peak ozone at 1200 PST suggests that the ozone resided in the eastern portion of the channel in the early morning hours. Winds during the night at Platform Habitat were calm to very light with a general flow from the east. It is therefore possible that the ozone at Santa Barbara resulted from coastal emissions along the Ventura Coast on the 11th which drifted slowly offshore during the night. Subsequently, the pollutant cloud was transported westward through Goleta and El Capitan Beach.

3.3.3 September 18, 1983

3.3.3.1 General Meteorology

On September 18th, a significant low pressure center was present immediately west of Seattle (Figure 3-38). This center moved southeastward during the next 24 hours to southern Wyoming, with the cold front from the low center extending to the west through central California. Falling surface pressures in the inland areas resulted in onshore pressure gradients during the day on the 18th, but these were reversed in northern California by the morning of the 19th. High pressures aloft (500 mb) which had dominated in the southwest since September 11th were eroding rapidly with the approach of the low pressure trough. The principal high pressure area at 500 mb was centered over Baja California, well to the south of southern California.

Low clouds were present throughout the day at Pt. Mugu until 2000 PST. Generally overcast skies were reported except for broken conditions between 1100 and 1400 PST. Broken to overcast clouds were also recorded at Oxnard except for a brief period of scattered clouds from 1400-1500 PST. Santa Barbara also had low overcast clouds for the early part of the day, but these cleared to a scattered sky condition or less by 0900 PST. Visibilities at Pt. Mugu were 3 miles or less throughout the entire 24-hour period on the 18th.

Significant meteorological parameters for September 18, 1983 are shown in Table 3-15.

By September 18th the temperature at 850 mb had decreased by more than $3^{o}C$ from the values observed on September 12th but remained well above average. The surface pressure gradients from central California southward had increased substantially such that there was an increased onshore flow. The inversion base at Pt. Mugu was considerably higher than observed on September 12th but south to southeasterly winds continued at 1000 m agl within the temperature inversion.

SUNDAY, SEPTEMBER 18, 1983

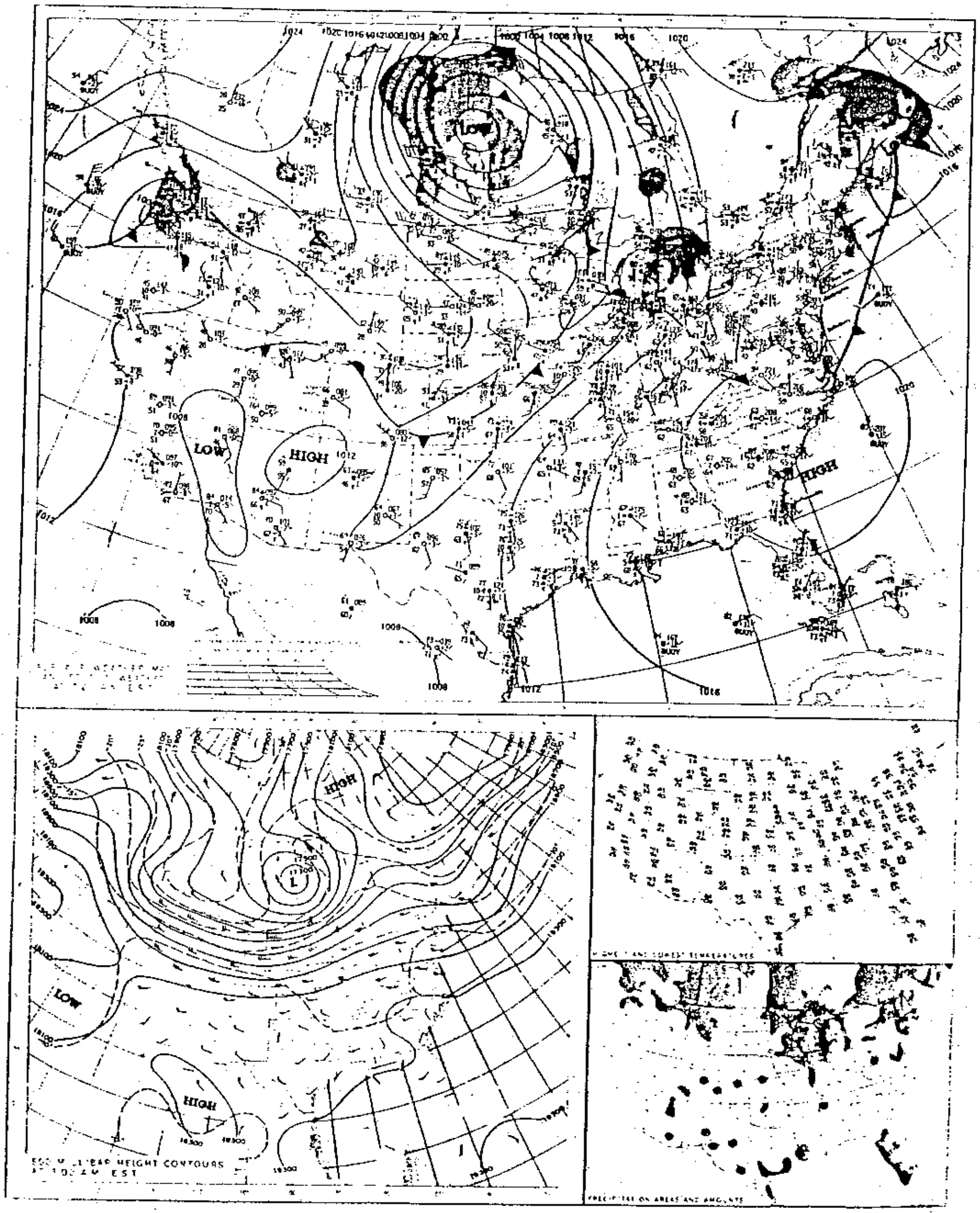

Figure 3-38. Surface and 500 mb Synoptic Weather Maps for 18 September 1983 at 0400 PST.

Table 3-15. Meteorological Parameters for September 18, 1983

	9/18/83	Long Term Average*
850 mb temperature at 0400 PST at Vandenberg AFB	22.1°C	18.1°C
Surface Pressure Gradients (0400 PST)		
San Francisco-Reno	-0.7 mb	-1.2 mb
Los Angeles-Bakersfield	0.2	-0.1
Los Angeles-Las Vegas	2.9	1.6
Inversion Base		
Pt. Mugu (1055 PST)	310 m agl	
Pt. Mugu (1228 PST)	322	
Pt. Mugu (1355 PST)	411	
Upper Winds (1000 m agl)		
Pt. Mugu (1055 PST)	117°/2.5 m/s	
Pt. Mugu (1228 PST)	143°/3	
Pt. Mugu (1355 PST)	182°/1.5	

*average September values (1980-83).

3.3.3.2 Transport Winds

Table 3-16 gives the surface wind observations for a number of locations on September 18th:

Table 3-16. Surface Transport Wind Summary for September 18, 1983

Time (PST)	Laguna Peak (deg./m/s)	Platform Grace (deg./m/s)	Pt. Mugu (deg./m/s)	Santa Barbara (deg./m/s)
0600	150/2	036/2.0	calm	030/2
0800	90/3	348/2.0	010/1	calm
1000	130/3	221/1.0	200/2	170/3
1200	160/2	265/2.6	250/2	220/3
1400	140/4	234/3.7	280/3	230/5
1600	150/3	246/2.6	280/3	190/2
1800	80/3	245/2.6	300/2	230/2
2000	110/3	260/2.6	300/2	190/4
2200	calm	242/2.3	320/2	250/2

The doppler acoustic sounder wind observations at Simi for September 18th are summarized in Table 3-17:

Table 3-17. Doppler Acoustic Sounder Winds at Simi at 1000 m msl for September 18, 1983

Time (PST)	Wind (deg./m/s)	Time (PST)	Wind (deg./m/s)
0800	119/4.9	1600	187/1.6
1000	162/9.8	1800	181/1.7
1200	127/3.6	2000	146/2.3
1400	155/3.2	2200	133/4.2

3.3.3.3 Mixing Heights

Observed mixing heights as obtained from aircraft spirals on September 18th are shown in Table 3-18.

Table 3-18. Mixing Heights from Aircraft Soundings on September 18, 1983

	Time (PST)	Mixing Depth (m agl)
Camarillo (sfc. elev. 25 m)		
	0550	150
	1029	375
	1440	450
Pt. 2 (3 mi SSW Laguna Peak)		
	0610	stratus
	1041	250
	1451	(350) top of stratus
Pt. 3 (13 mi SSW Laguna Peak)		
	0635	stratus
	1103	400
	1514	400
Westlake Reservoir (sfc. elev. 305 m)		
	0714	425
	1143	650
	1608	725
Simi (sfc. elev. 335 m)		
	0735	400
	1202	600
	1625	650

The higher mixing heights on September 18th reflected a return to more normal onshore flow conditions and a decrease in the temperatures aloft. Associated with these changes were the more prevalent stratus cloud conditions over the water.

3.3.3.4 Regional Ozone Concentrations

Maximum ozone concentrations in the South Central Coast Air Basin on September 18th are given in Table 3-19 together with the hours when the peak concentrations occurred and the time of maximum occurrence.

Maximum ozone concentrations on September 18th were relatively high in the inland and elevated areas such as Simi, Rocketdyne, and Laguna Peak. Peak concentrations along the coast were relatively low. As suggested later, this configuration is characteristic of deeper mixing layers than occurred on September 11-12th.

3.3.3.5 Transport Analysis

Figure 3-39 gives the hourly ozone concentrations at several locations in Ventura County for September 18, 1985. At Ojai, Piru and Simi, the peak

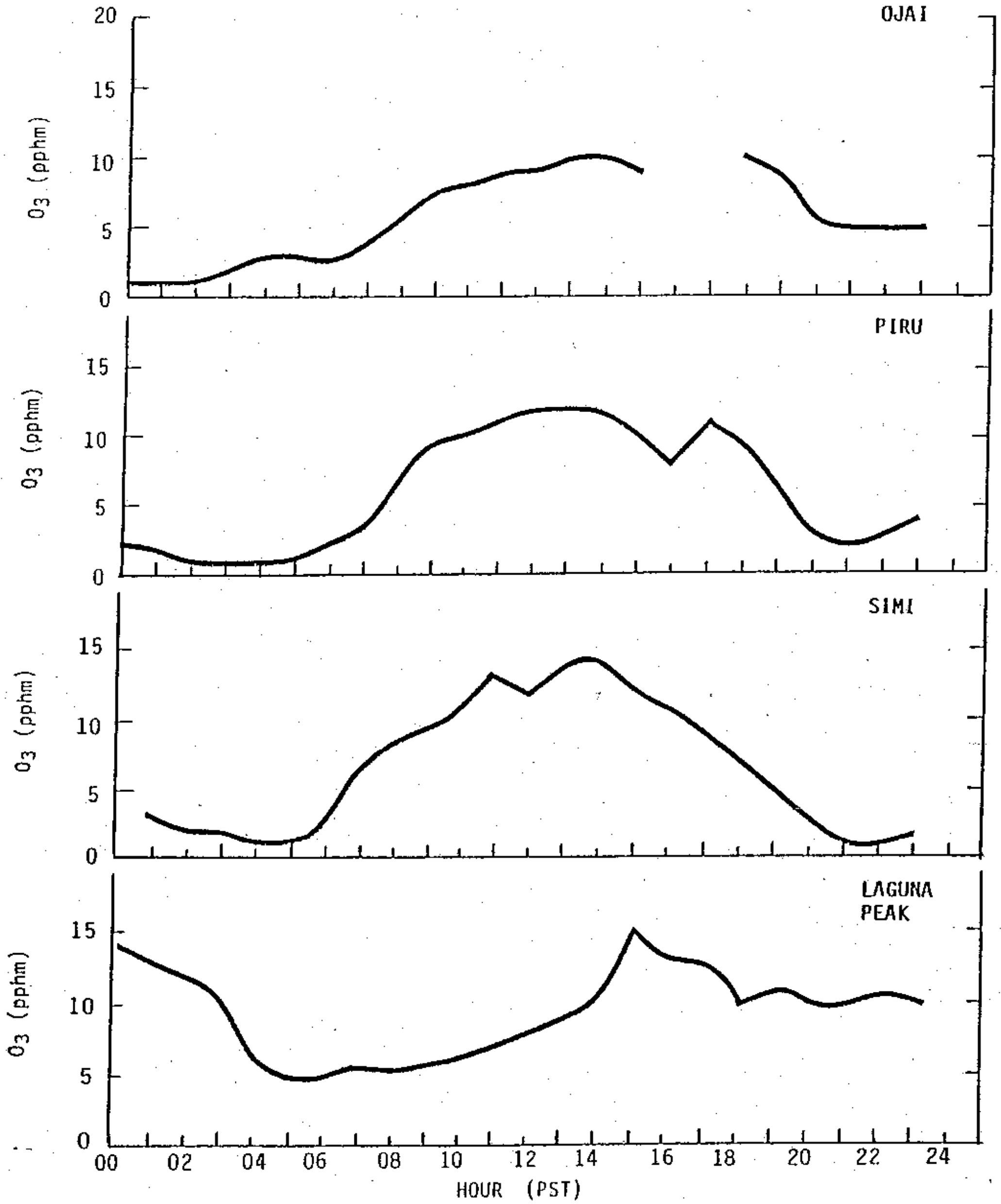

Figure 3-39. Hourly Average Ozone Concentrations for 18 September 1983.

Table 3-19. Maximum Ozone Concentrations on September 18, 1983

Location	Maximum Concentration (pphm)	Time of Maximum (PST)	Wind (°/m/s)
Ojai	10	13-14,18	200/334/4
Piru	12	12-14	249/M
Simi	15	14	281/4
Thousand Oaks	10	12-13	
Rocketdyne	14	13-14	159/3
El Rio	7	9-11,13	
Laguna Peak	15	15	170/2
Ventura	M	M	
La Conchita	4	12-17	
Santa Barbara	6	16	190/2
Goleta	6	14-15	
El Capitan Beach	6	13-17	

ozone occurred between 1200 and 1400 PST. A second peak was apparent at Ojai and Piru but not at Simi. The highest ozone concentration at Laguna Peak was recorded at 1500 PST. In consideration of the east to southeast flow which was present throughout the day at Laguna Peak, the ozone maximum at 1500 PST was probably the result of transport from the Los Angeles area. From the standpoint of progressive transport of this peak farther into the South Central Coast Basin, the late peaks at Piru and Ojai are in agreement with such a hypothesis.

High ozone concentrations were observed at Laguna Peak throughout the night of September 17th-18th. The influx of ozone at that location commenced at 1800 PST on the 17th under northwestly winds. A peak value of 15 pphm was observed at 2200 PST. At about the same time, the wind shifted to east and southeast with high speeds (0-2 m/s) where it remained for the balance of the night. There was therefore a layer of ozone at 450 m msl available on the morning of the 18th, at least in the vicinity of Laguna Peak.

At the observing locations in Santa Barbara County on the 18th, peak ozone values were 6 pphm and were not influenced by any transport from the southeast.

Figure 3-40 shows the early morning aircraft sounding at Camarillo on September 18th. The peak ozone recorded was 8 pphm in an elevated layer of ozone and particles (b_{scat}) which was present above about 500 m msl. Presumably this layer may have been part of the same pollutant layer observed at Laguna Peak during the night and early morning hours. The sounding in Figure 3-41 was taken at Pt. 2 (3 mi SSW of Laguna Peak). The presence of stratus clouds eliminated the lower part of the sounding, and a maximum ozone concentration of 10 pphm was observed above the stratus.

Figures 3-42 and 3-43 give the soundings at Westlake Reservoir and Simi on the early morning flight. In both soundings two aerosol layers were

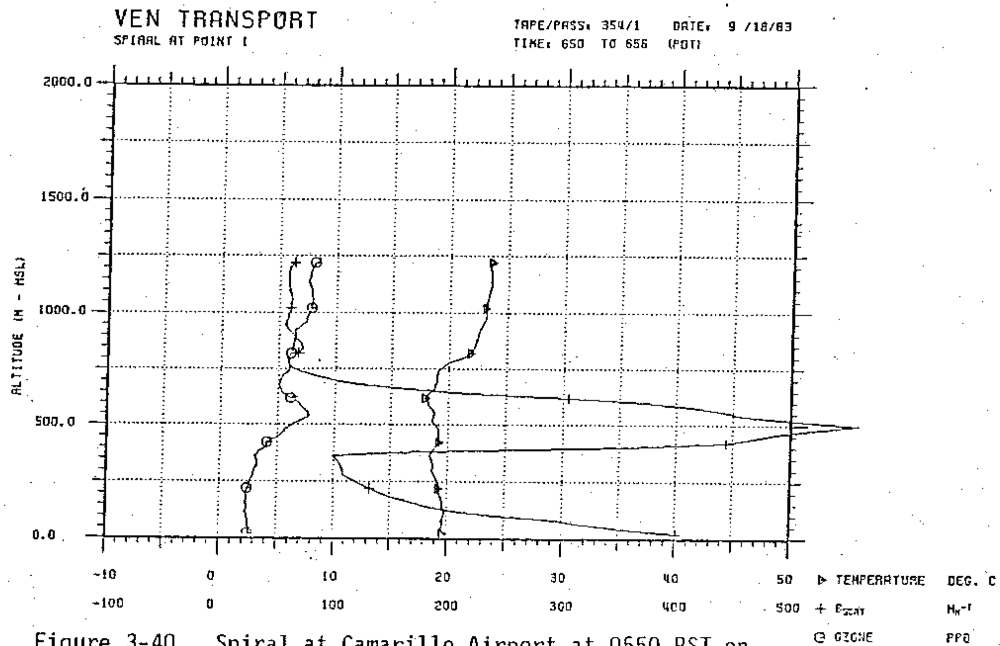

Figure 3-40. Spiral at Camarillo Airport at 0550 PST on September 18, 1983.

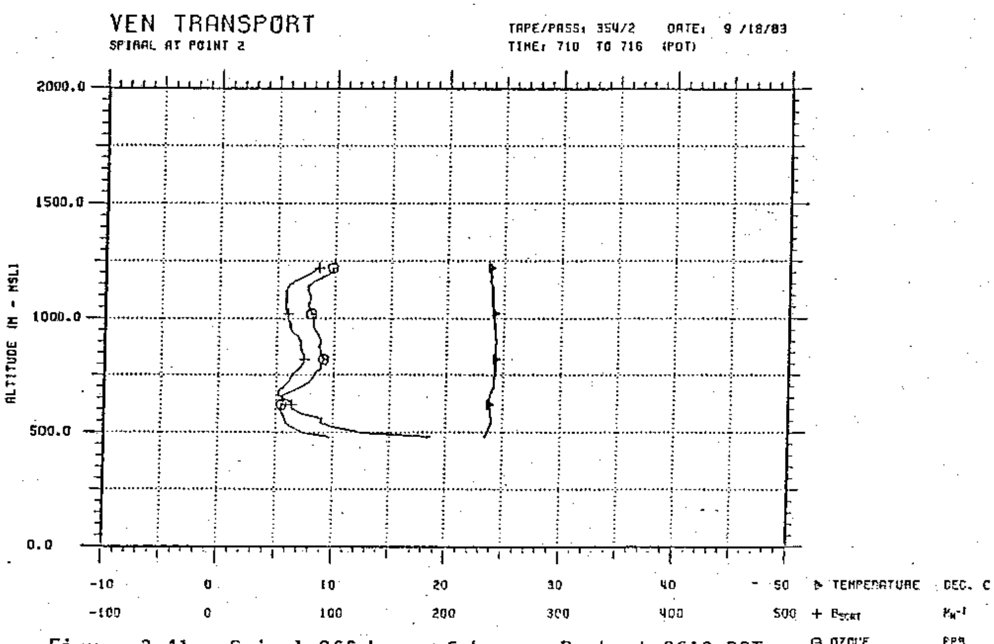

Figure 3-41. Spiral Offshore of Laguna Peak at 0610 PST on September 18, 1983.

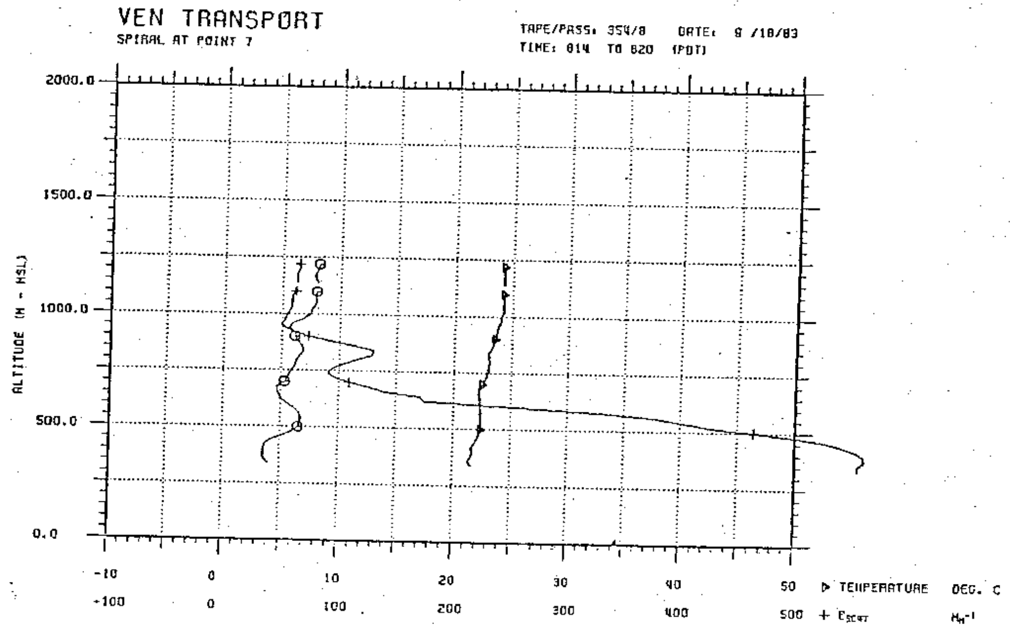

Figure 3-42. Spiral at Westlake Reservoir at 0714 PST on September 18, 1983.

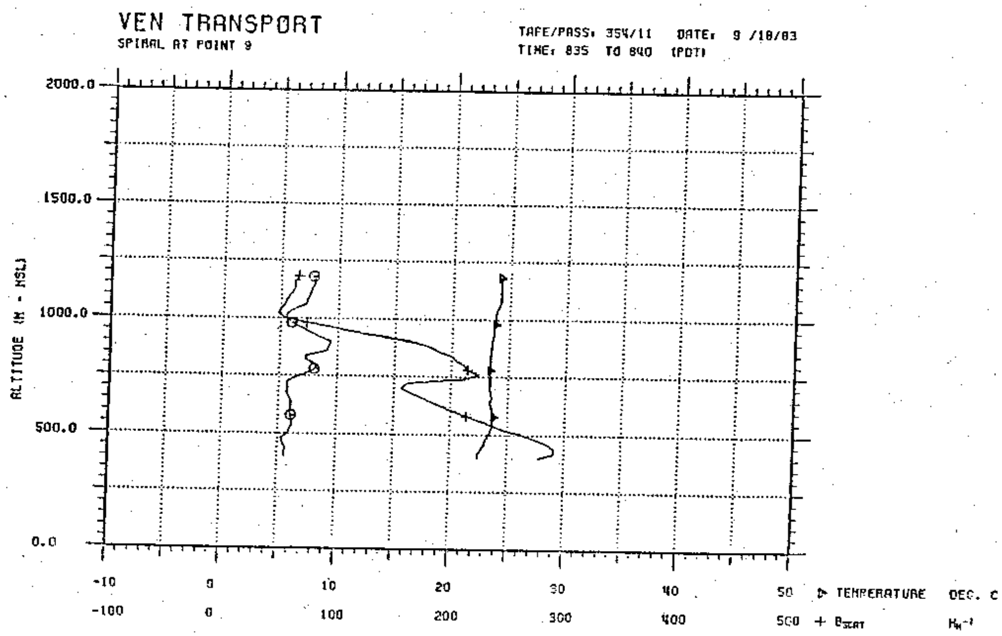

Figure 3-43. Spiral at Simi at 0735 PST on September 18, 1983.

observed below 1000 m msl which is the approximate height of much of the Simi Hills ridge line. A similar profile is shown for Piru in Figure 3-44 except that ozone concentrations of 11 pphm were observed at about 400 m msl. In view of the similar observations at Camarillo, Laguna Peak and the inland locations, it is suggested that these upper layers represented carryover of pollutants from the previous day as well as nocturnal transport from the southeast.

The effect of this layer aloft at Piru is shown in Figure 3-45. The time history of hourly ozone at Piru on September 18th shows a sharp increase from 0800 to 0900 PST which appears to represent the mixing downward of the ozone aloft which was shown in Figure 3-44. Although the wind directions at Rocketdyne and Piru were both easterly or southeasterly, the ozone increase at Rocketdyne was not as sharp as at Piru and did not occur until an hour after the increase at Piru. It is therefore suggested that mixing down of pollutants from the previous day was the likely cause of the increase at Piru.

Figures 3-46 and 3-47 show midday soundings at Westlake Reservoir and Simi. The soundings show well-mixed layers to at least 600 m msl with little change in ozone concentration above this level. The ozone concentrations and wind direction at Rocketdyne at the time of the Simi sounding indicate that the concentrations aloft were being transported into the area from the southeast.

Figure 3-48 shows the late afternoon sounding at Camarillo. On this sounding, there was a well-mixed layer to 500 m msl with moderately low ozone concentrations. Aloft, the ozone concentrations increased within the inversion to 13 pphm at 750 m msl. This represents an increase from 9 pphm at that level on the midday sounding.

Figure 3-49 shows the late afternoon sounding at Pt. 2 (3 mi SSW of Laguna Peak). This sounding indicates that a major ozone layer had advected into the area between 300 and 650 m msl. A peak ozone value of 34 pphm was recorded in this layer at 450 m msl. As indicated, the layer was located within the temperature inversion.

Figure 3-50 is a horizontal traverse from Pt. 2 to Pt. 3 at 396 m msl. The data show that the high ozone concentrations did not extend as far offshore as Pt. 3 but were confined to regions closer to the coast. This is further confirmed by the sounding at Pt. 3 (Figure 3-51) which showed a maximum ozone concentration of 11 pphm.

Afternoon aircraft soundings at Westlake Reservoir and Simi are shown in Figures 3-52 and 3-53. Both soundings show a marked, low-level mixing layer to about 750 m msl. This layer was characterized by southwest winds and transport from the west. Aloft there is a large difference in ozone concentrations between the two soundings with much higher values at Simi. Winds at these levels were from the southeast so that the high concentrations at Simi represent transport from the San Fernando Valley which did not affect the Westlake area.

Figure 3-54 is a sounding made at Santa Paula at 1657 PST which shows the major effect of the transport of the ozone layer shown in Figure 3-49. An ozone layer was present in the Santa Paula sounding from 250 to 700 m msl with a peak value of 24 pphm at 400 m msl. This layer was undercut by a

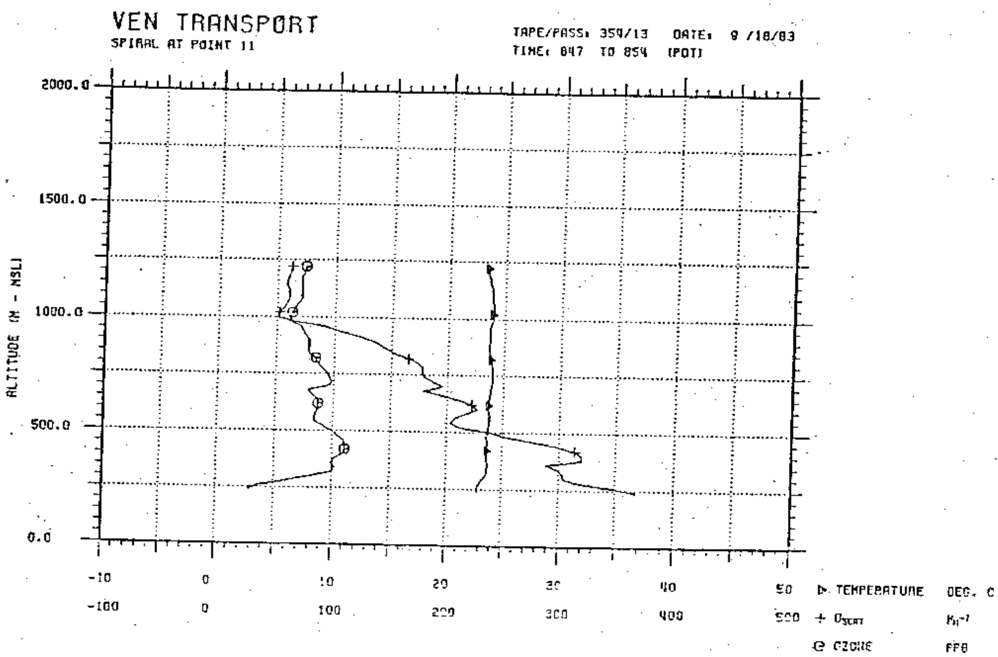

Figure 3-44. Spiral at Piru at 0747 PST on September 18, 1983.

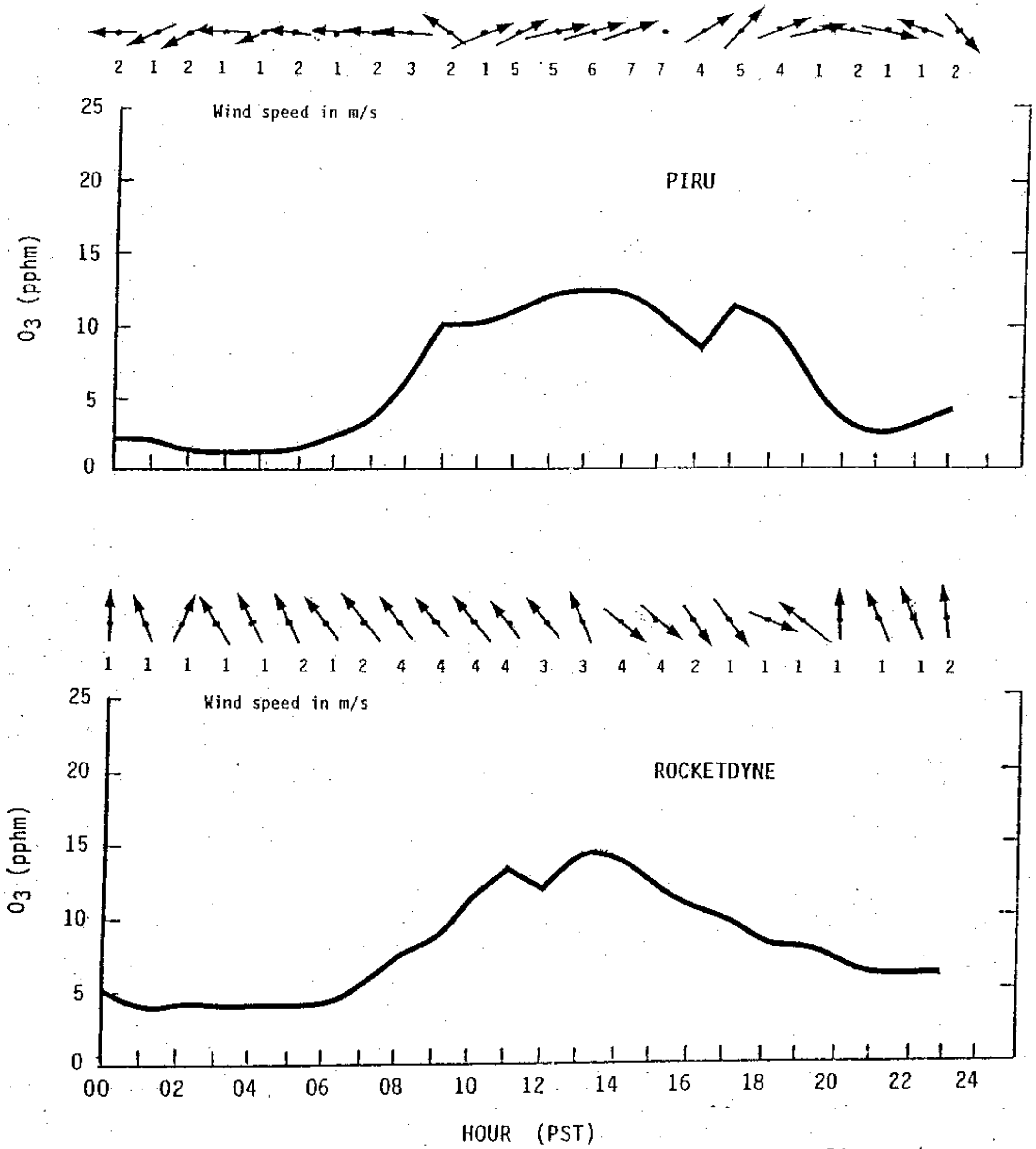

Figure 3-45. Hourly Ozone, Wind Speed, and Wind Direction at Piru and Rocketdyne on 18 September 1983.

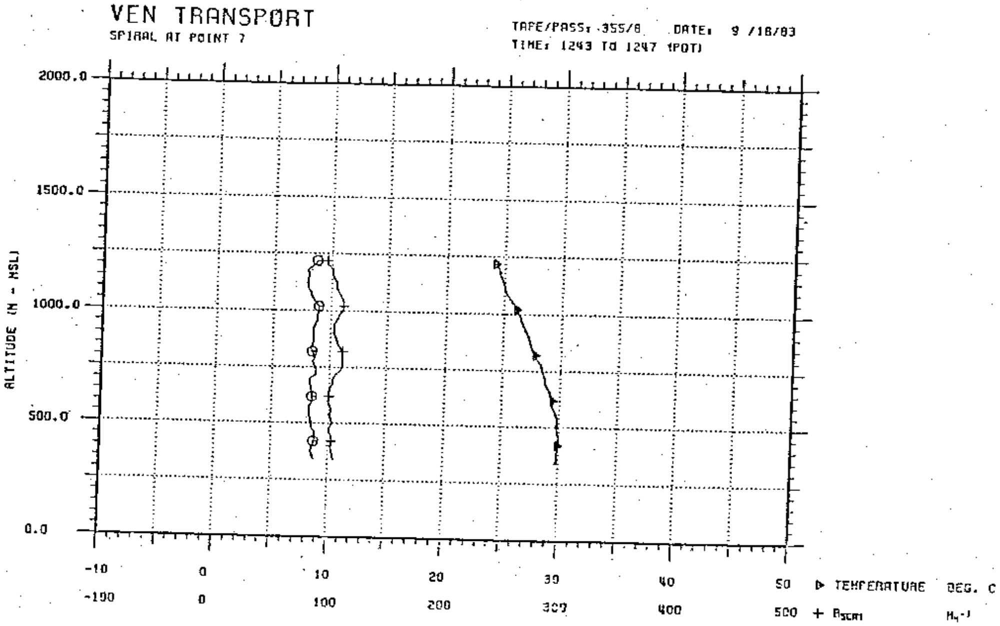

Figure 3-46. Spiral at Westlake Reservoir at 1143 PST on September 18, 1983.

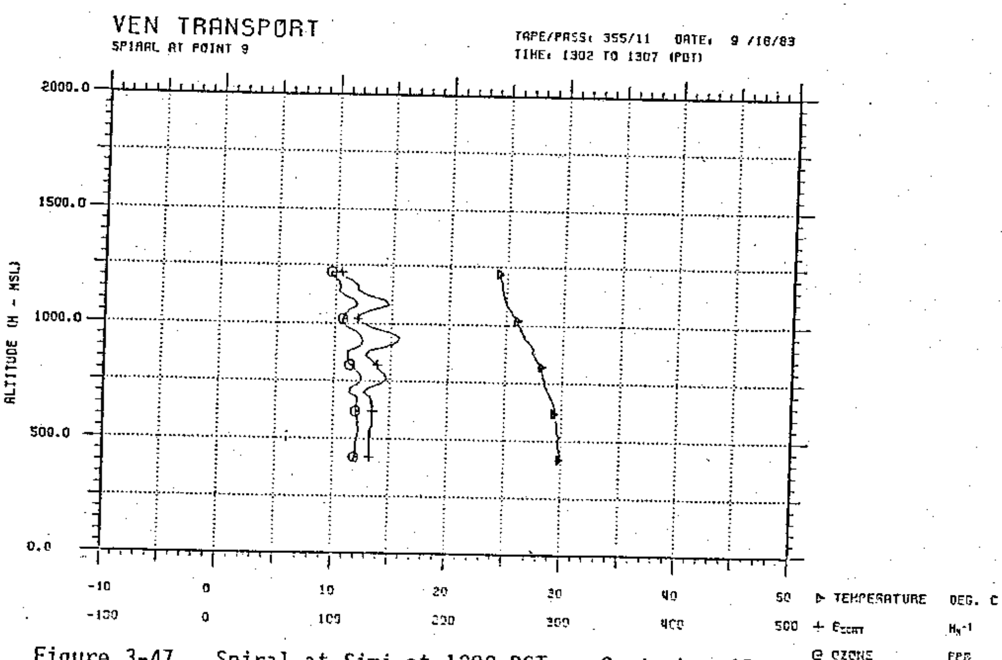

Figure 3-47. Spiral at Simi at 1202 PST on September 18, 1983.

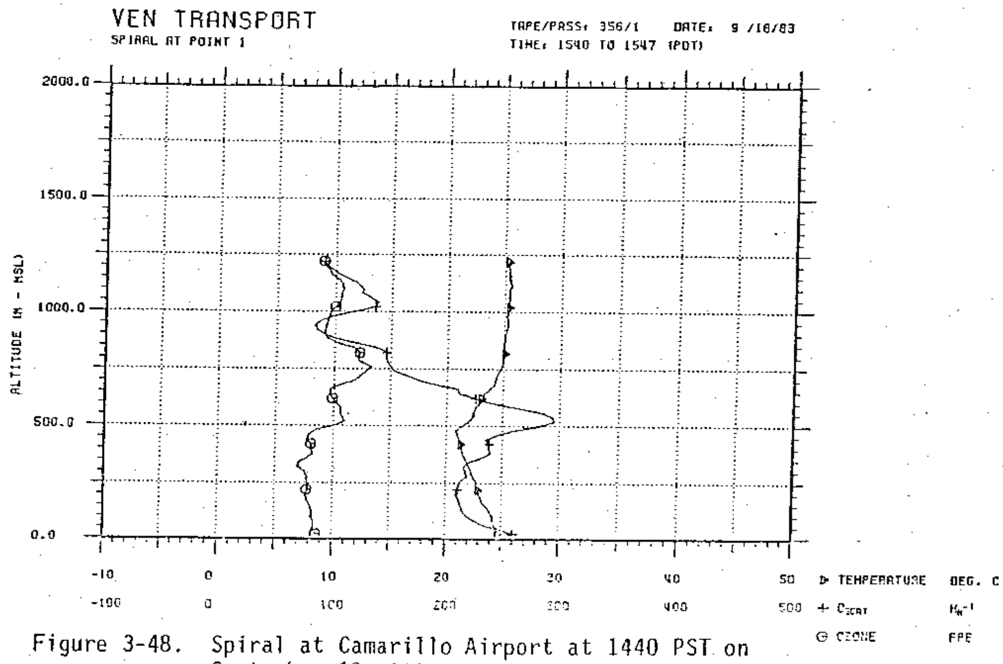

Figure 3-48. Spiral at Camarillo Airport at 1440 PST on September 18, 1983.

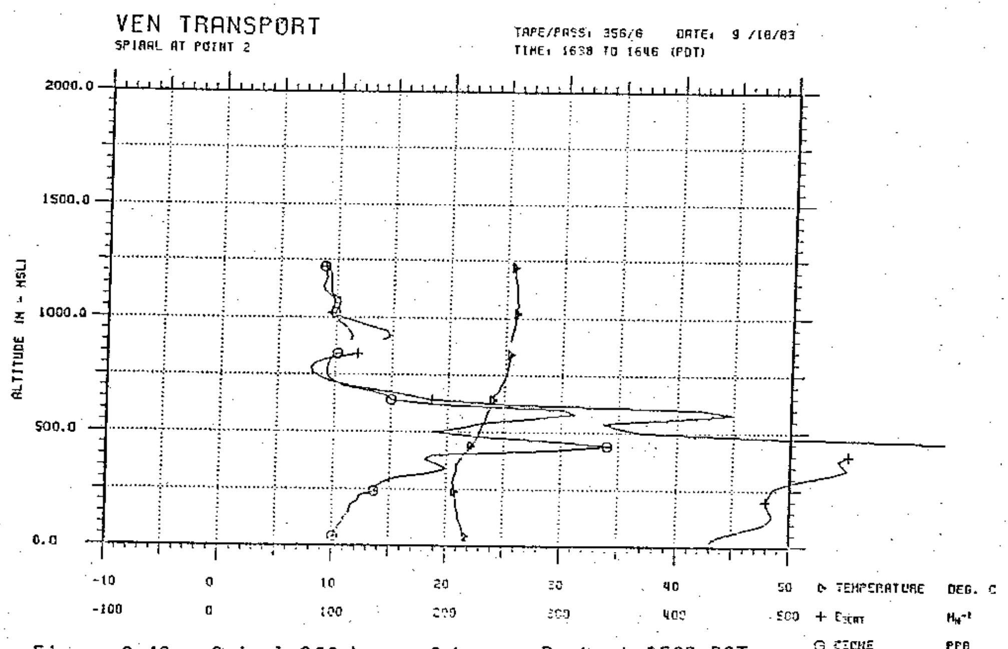

Figure 3-49. Spiral Offshore of Laguna Peak at 1538 PST on September 18, 1983.

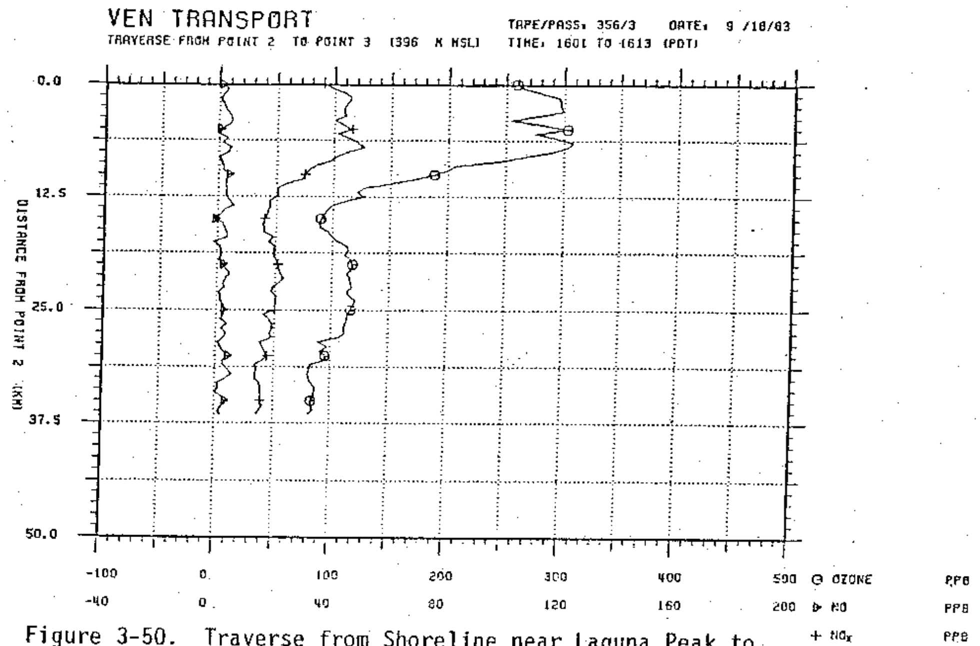

Figure 3-50. Traverse from Shoreline near Laguna Peak to 10 Miles South of Pt. Mugu at 1501 PST on September 18, 1983.

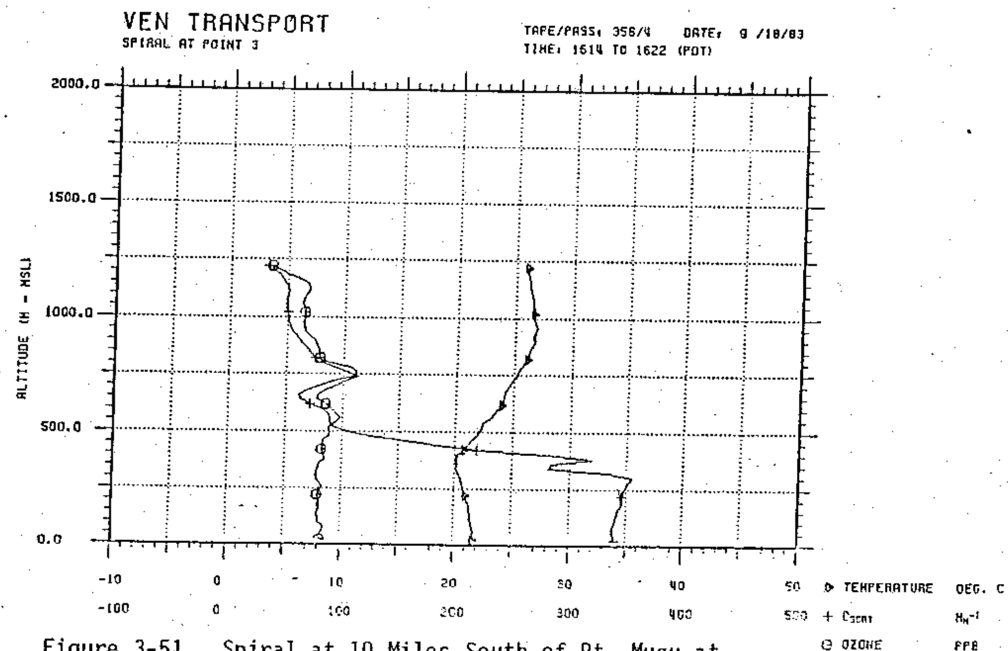

Figure 3-51. Spiral at 10 Miles South of Pt. Mugu at 1514 PST on September 18, 1983.

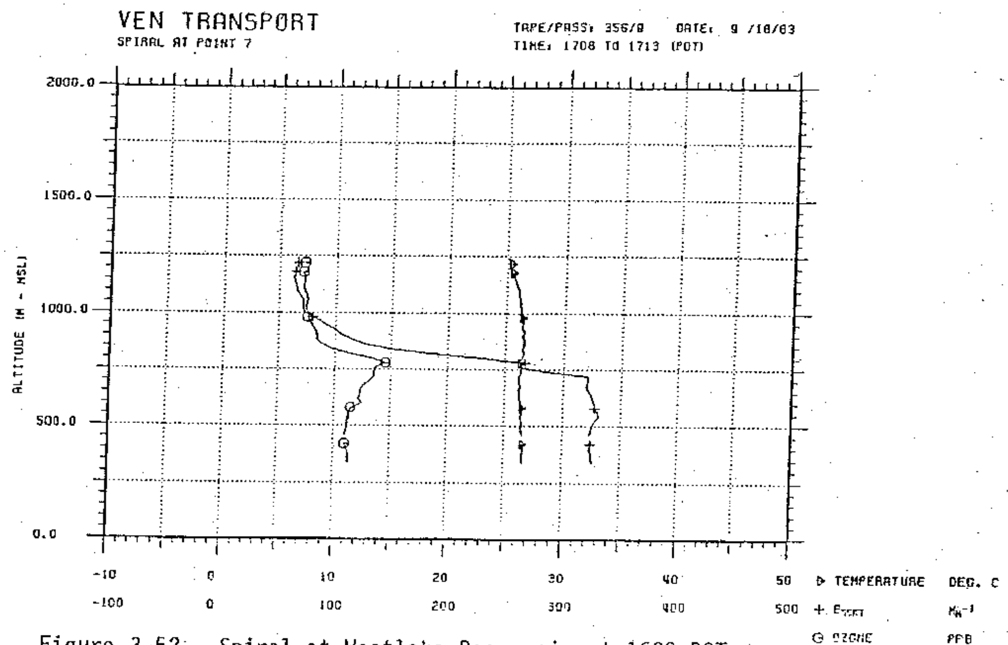

Figure 3-52. Spiral at Westlake Reservoir at 1608 PST on September 18, 1983.

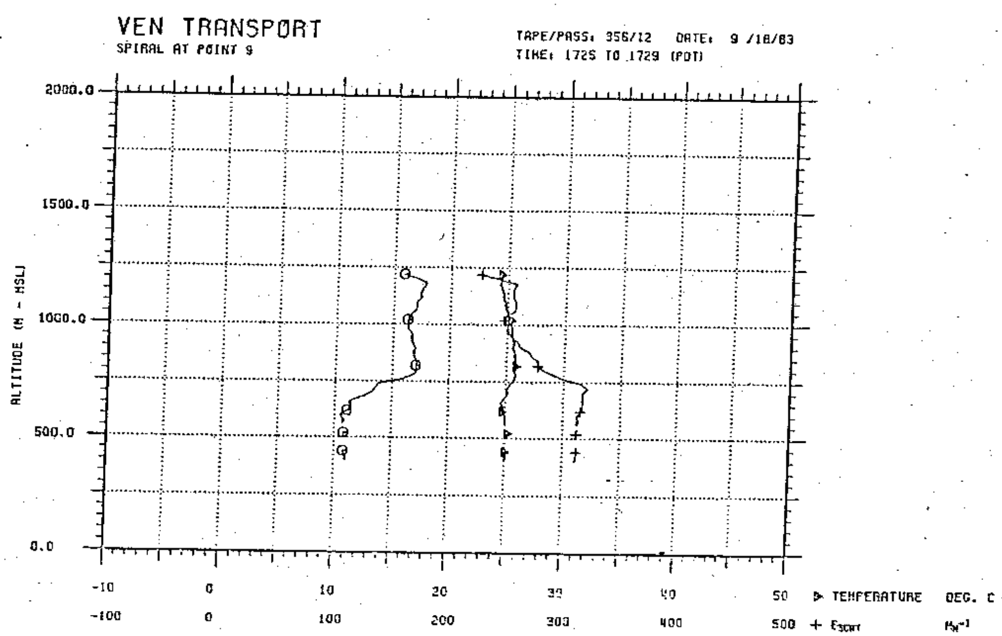

Figure 3-53. Spiral at Simi at 1625 PST on September 18, 1983.

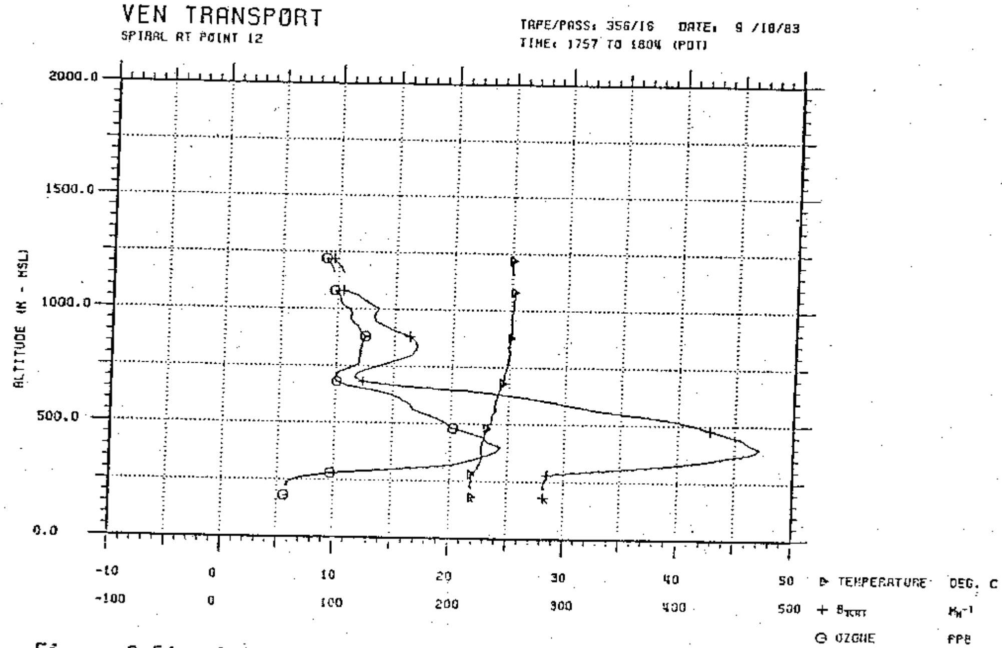

Figure 3-54. Spiral at Santa Paula at 1657 PST on September 18, 1983.

shallow (200 m) layer of cool, marine air which prevented the upper ozone concentrations from reaching the surface. Farther inland (Ojai and Piru) surface heating increased and the effect of these concentrations was seen at the surface in terms of the late afternoon ozone peaks at the two locations (Figure 3-39).

The transport conditions of September 18th are summarized in Figure 3-55. A major transport route offshore was observed from the South Coast Air Basin into the South Central Coast Basin. The main portion of the transport occurred rather late in the day with peaks extending from Laguna Peak (1500 PST) to Piru and Ojai (1600-1700 PST). Aircraft soundings at Pt. 2 and Santa Paula supported the description of this transport route.

3.4 SUMMARY OF SEPTEMBER 1983 CASE STUDIES AND METEOROLOGY-OZONE RELATIONSHIPS IN VENTURA COUNTY

Three cases of transport from the South Coast Air Basin into the South Central Coast Air Basin have been described in the previous section. A brief summary and comparison of these cases follows:

1. September 11, 1983

   850 mb temperature: 24.5°C
   Offshore pressure gradients
   030° wind direction at 1000 m at Loyola-Marymount (0600 PST)
   Weak seabreeze at Pt. Mugu
   Very low mixing heights
   Peak ozone concentration at Pt. 2 - 26 pphm (1426 PST)
   Maximum surface ozone concentrations higher along coast than inland

   Conclusion:
   a. Pollutants were transported at low-levels from the South Coast into the coastal areas of Ventura County.
   b. Local pollutants from September 10th reimpacted Santa Barbara on the 11th.

2. September 12, 1983

   850 mb temperature: 25.5°C
   Offshore pressure gradients
   132° wind direction at 1000 m at Pt. Mugu (0900 PST)
   Very weak seabreeze at Pt. Mugu
   Low mixing heights
   Peak ozone concentration at Pt. 2 - 22 pphm (1442 PST)
   Maximum surface ozone occurred inland in Ventura County but exceedances also occurred along the coast at Ventura and Santa Barbara

   Conclusion:
   a. Direct transport across Simi Hills into eastern Ventura County occurred.
   b. Pollutants were transported offshore from the South Coast Basin into Ventura and Ojai.
   c. Local pollutants from September 11th reimpacted Santa Barbara on the 12th.

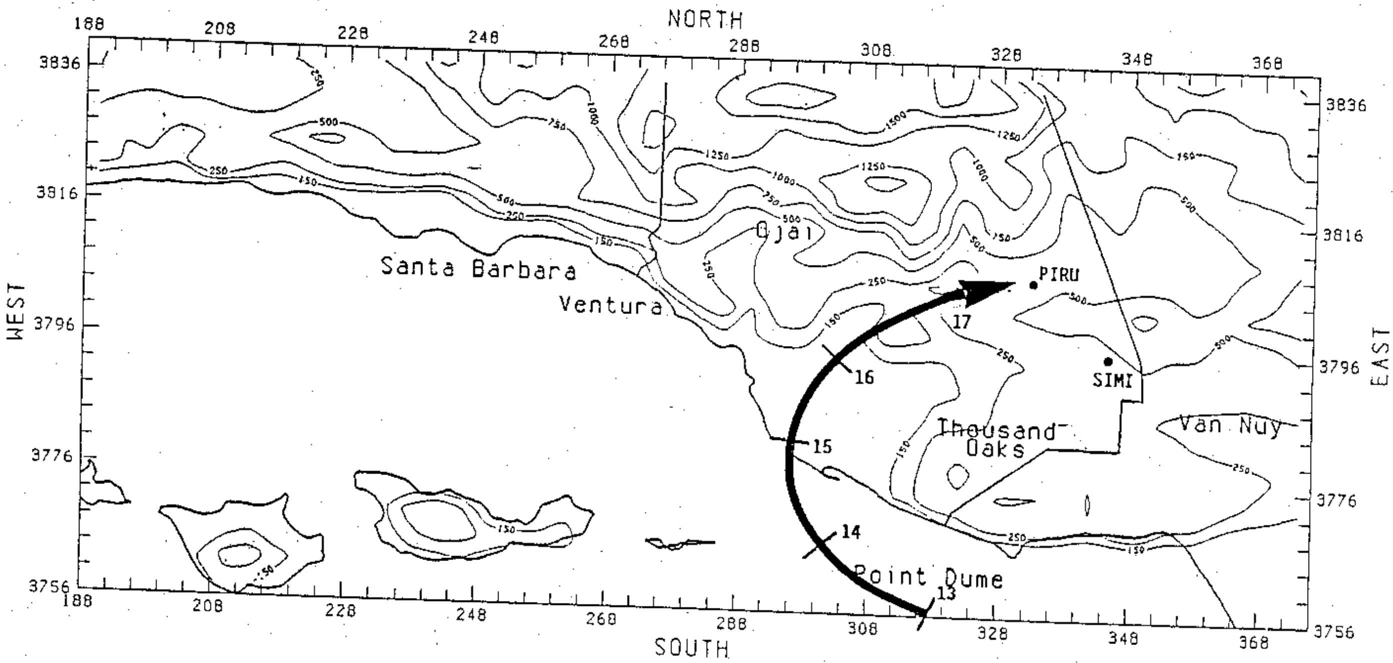

Figure 3-55. Approximate Trajectory Arriving at Piru During the Hour of Maximum Ozone on September 18, 1983. (Hours shown are PST.)

3. September 18, 1983

850 mb temperature: 22.1°C
Offshore pressure gradient Las Vegas-Los Angeles
117° wind direction at 1000 m at Pt. Mugu (1055 PST)
Moderate seabreeze at Pt. Mugu
Moderate mixing heights
Peak ozone concentration at Pt. 2 - 34 pphm (1451 PST)
Maximum surface ozone concentrations occurred inland in Ventura County and at Laguna Peak

Conclusion:
a. Pollutants from September 17th impacted surface concentrations on the 18th through entrainment of a layer aloft.
b. Transport from the South Coast Air Basin into Ojai and Piru occurred.

There are several common features which characterize these transport days. Three of the most important appear to be the occurrence of warm temperatures at 850 mb, offshore winds along the coast at 1000 m in the morning and the appearance of high ozone concentrations at Pt. 2 (3 mi SSW of Laguna Peak). High ozone values at Laguna Peak are also usually associated with southeast winds and transport from the South Coast Air Basin.

The impact of transport into the South Central Coast Basin depends to a great extent on the depth of the associated mixing layer. Shallow mixing depths tend to produce high ozone concentrations along the immediate coast while deeper mixing layers result in a more elevated ozone layer and impact on the higher elevation, inland areas.

A summary of September 1983 days is given in Table 3-20. Included in the table is the 0400 PST Vandenberg AFB 850 mb temperature, the occurrence of morning winds (1000 m) at Pt. Mugu from the northeast through south, the daily peak ozone aloft measured at Pt. 2, and the occurrence of high ozone concentrations at Laguna Peak. These factors should be related to the occurrence or non-occurrence of surface ozone concentrations greater than 12 pphm as indicated.

Several summary comments can be made from Table 3-20.

1. For the month of September 1983, ozone exceedances in Ventura County occurred only with 850 mb temperatures of 21.7°C or more.

2. Exceedances in Ventura County occurred with morning winds (1000 m) at Pt. Mugu between northeast and south. Such winds also occurred on some non-exceedance days but with lower temperatures aloft. The potential for transport from the South Coast Air Basin would be expected under such conditions. The importance of the transport undoubtedly depends on the low-level entrapment of pollutants for which warm temperatures aloft are an indicator. Thus, significant transport of ozone from the South Coast Basin should usually be accompanied by the concurrence of northeast to south Pt. Mugu winds and warm temperatures aloft.

Table 3-20. Summary of September 1983 Data

	Ventura	Laguna Peak	El Rio	Piru	Simi	Vandenberg AFB 0400 PST 850 mb temp. (^oC)	Pt. Mugu 1000m 0500 PST Wind Direction NE-S	Max. Ozone at Pt. 2 O_3 (pphm)	Time (PST)
1						18.3	M	6	1629
2						21.4		10	0941
3		M			X	21.8	M	15	1041
4		M				18.1	M	22	1442
5	M	M				21.4	M	8	0951
6	M			X	X	23.0	X	M	
7					X	21.7	X	19	0957,1426
8						18.4	X	6	0526
9						19.8	X	3	0538
10		U				23.5	M	13	1553
11		O	X			24.5	M	26	1426
12	X	X		X	X	25.5	X	22	1442
13	X	X	X	X	X	25.6	X	M	
14		X		X	X	24.6		20	0954,1507
15		O		X	X	25.6	X	16	0936
16		X	M		X	24.4	X	27	0602
17		X		X	X	22.8	M	17	1431
18	M	X			X	22.1	X	34	1451
19	X	X				22.5	X	M	
20						21.2	X	8	0931
21						M	X	M	
22		M				14.8	X	4	1433
23						13.4	X	3	0557
24	M					13.2	M		
25	M					13.7	X		
26						7.9		6	1432
27						10.3	X		
28						10.2	X		
29		M				8.8			
30		M				6.3			

U = Maximum ozone 10-12 pphm
X = Maximum ozone > 12 pphm, or wind direction from NE-S
M = Missing data

3. All of the exceedance days when aircraft soundings were available showed high ozone concentrations (at least 15 pphm) at Pt. 2 (3 mi SSW of Laguna Peak). Peak values at Pt. 2 of 13 pphm or more were recorded on two non-exceedance days (September 4th and 10th) when maximum ozone concentrations in Ventura County were 12 and 11 pphm, respectively.

4. Maximum ozone concentrations of 10 pphm or more were observed at Laguna Peak on each day from September 10th to September 19th. An ozone exceedance occurred in the county on each of these days except for the 10th. All of these days also experienced high ozone offshore at Pt. 2. One occurrence of high ozone at Pt.2 (September 7th) was observed without a similarly high value at Laguna Peak. Presumably, the ozone layer remained offshore of Laguna Peak on that day.

Utilizing the results of the case studies, the occurrence of high ozone concentrations at Laguna Peak and Pt. 2, together with easterly winds at Pt. Mugu, should signify a contribution of South Coast Air Basin transport into Ventura County. This combination occurred from September 10th to 19th. A similar but less substantiated case can be made for possible transport on September 3rd, 4th and 7th where offshore concentrations were high but gaps in the remaining data existed.

High ozone concentrations at Ventura and El Rio in September 1983 occurred at the beginning of an extended period of warm temperatures aloft. This represented the early stage in the high pressure development when the offshore winds tended to reach their peak and mixing heights were relatively low. As the high pressure moved to the east, the mixing layers tended to deepen and the seabreeze was reestablished, with the inland areas usually receiving higher concentrations than the coastal sections.